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# Cephalometric Identification*

## A Proposed Method of Identification of War-Dead by Means of Roentgenographic Cephalometry

*Viken Sassouni, D.F.M.P., M.Sc. (Dent.), D.Sc. (Dent.)* **

### Introduction

After World War II and the Korean conflict the identification of remains of American military personnel by all techniques then available left a small but important number of individuals unidentified. On the basis that, (1) the skull is one of the best preserved parts of the human body, (2) the head and face are regarded as highly individual, and (3) that there exists an apparatus which permits the taking of standardized roentgenographic films of the head and face in the lateral (sagittal) and frontal (postero-anterior) views, a potential new method of systematic identification was envisioned.

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* Abstracted from a thesis submitted on January 29, 1958 to the faculty of the Graduate School of Medicine of the University of Pennsylvania in partial fulfillment of the requirements for the degree of Doctor of Science in Dentistry. The complete thesis is being published by The Headquarters, Quartermaster Research and Development Command, U. S. Army, Natick, Massachusetts.

Presented at the 10th Annual Meeting of the American Academy of Forensic Sciences, February 27, 1958, Cleveland, Ohio.

Presented at the 27th Annual Meeting of the American Association of Physical Anthropologists, April 11, 1958, Cambridge, Mass.

The research upon which this study is based was supported by Contract #DA-19-129-QM-739, Mod. #1, Quartermaster Research and Development Command, U. S. Army.

The final test of identification, conducted in the presence of the Faculty, was supported by the University of Pennsylvania Computer Center and the National Science Foundation.

** Assistant Professor of Physical Anthropology, Graduate School of Medicine, University of Pennsylvania, Philadelphia Center for Research in Child Growth.

This study was undertaken with the purpose of investigating:

1. the standardization of roentgenographic cephalometric techniques (problem of error);
2. the individuality of the head and face (problem of variation and correlation);
3. the possible application of these findings for use as a means of identification (index of selectivity).

This is, in essence, the problem raised by the Quartermaster Research and Development Command, U. S. Army: "What are the five measurements in the head and face (as seen in the postero-anterior and lateral X-ray films) which are the most variable, the least correlated, and the most reliable, that can be used for identification purposes? The mandible should not be included in more than one measurement. The test should be carried out on 500 adult males above eighteen years of age."

The implementation of the results of this study by the military authorities as an identification procedure would necessitate:

1. taking the cephalometric X-rays of all male military personnel;
2. in case of large numbers of casualties the selection of films on all unidentified or missing persons;
3. taking cephalometric X-ray films of remains;
4. matching the unknown films of (3) with the known films of (2) by a system of coding of the five craniofacial measurements, which, in effect, amounts to individual identification.

This last phase is the core of the present study.

## Investigation

The use of X-ray films of the head for the purpose of identification has been thoroughly reviewed by Cornwell (1) in a recent paper. The frontal sinus area particularly has been found highly individual by Schuller (2); however, no systematic work has developed as yet from these observations. Thorne and Thyberg (3) have suggested the possibility of

using roentgenographic cephalometry for identification purposes. They have matched, by direct inspection, one hundred head X-ray films taken twice. However, here again, no systematic work has been carried out to demonstrate what areas or dimensions express most accurately the individuality of a person, permitting, therefore, coding and selection.

Craniometry and soft tissue cephalometry have already shown the variability of the cranio-facial components and suggested that this was an area of high individuality.

Roentgenographic cephalometry was first developed when instruments of high standardization (1931, Broadbent (4) in U. S., Hofrath (5) in Germany) were created in order to obtain the record of cranio-facial architecture on the living. The primary concern being the study of growth, it is not surprising that most of the investigations have been conducted by orthodontists. Diverse analyses have been devised to define quantitatively the "normal" face, and, by contrast, to assess the deviations from these standards. They can be grouped as linear, angular, or positional analyses. Due to particular focus of interest specific to orthodontics, the lateral view only has been generally investigated. As far as growth of the head in adulthood is concerned, no reliable information exists. Some indications suggest that, in certain diameters, increase might occur after twenty years of age. Post-mortem shrinkage of remains might influence some proportions. Longitudinal studies are required in respect to these problems.

The present study has been undertaken in order to investigate the possibility of selecting the most individual characteristics in the cranio-facial complex as seen in the X-ray films. With proper coding these individual characteristics might be used for identification purposes.

The material on which this study is based consists of 500 adult males that were X-rayed twice (one lateral and one postero-anterior film each time). The first set represents the ante-mortem (AM) records and the second set the post-mortem (PM) records.

The X-ray films were taken with a Broadbent-Bolton cephalometer, a highly standardized instrument, which orients the head in the Frankfort horizontal.

Preliminary tests were conducted to select the proper method of measurement. The Sassouni (6) analysis done on the lateral film gave good results for identification, but it involved a preliminary tracing of the bony structures. Furthermore, it required the presence of the mandible, in centric occlusion. For similar reasons angular and proportional measurements were tested but rejected. Linear measurements were retained.

On the postero-anterior film twenty-four measurements were taken from thirty subjects. (Fig. 1). The range of variation and the standard deviation were calculated for each measurement. The films of the AM and PM series were measured by two different persons and the total range of error assessed for each measurement. The ratio between standard deviation and error was calculated and only those in which the ratio $\frac{S.D.}{E.}$ was greater than two were retained. Two diameters were eliminated because of duplication. Thus, the selected measurements from the postero-anterior film are: bigonial breadth, mastoid to apex height, bimaxillary breadth, bizygomatic breadth, maximum cranial breadth, sinus breadth, incision height, and total facial height (7).

From the lateral film (Fig. 2) a similar study was done. The ratio between standard deviation and range of error was calculated for the twenty-four lateral measurements. Eight measurements with a ratio $\frac{S.D.}{E.}$ greater than two were selected (after eliminating overlapping measurements). These are: cranial height 8 cm. posterior, 4 cm. posterior, above, and 4 cm. anterior to Sella; cranial length along Nasion-Sella line, 4 cm. above, and 8 cm. above; total facial height Nasion-Menton.

The coefficient of correlation "r" was calculated between these sixteen measurements (8 postero-anterior and 8 lateral) taken from ninety subjects. The communalities (h) of each measurement were calculated (Thurstone). The index of

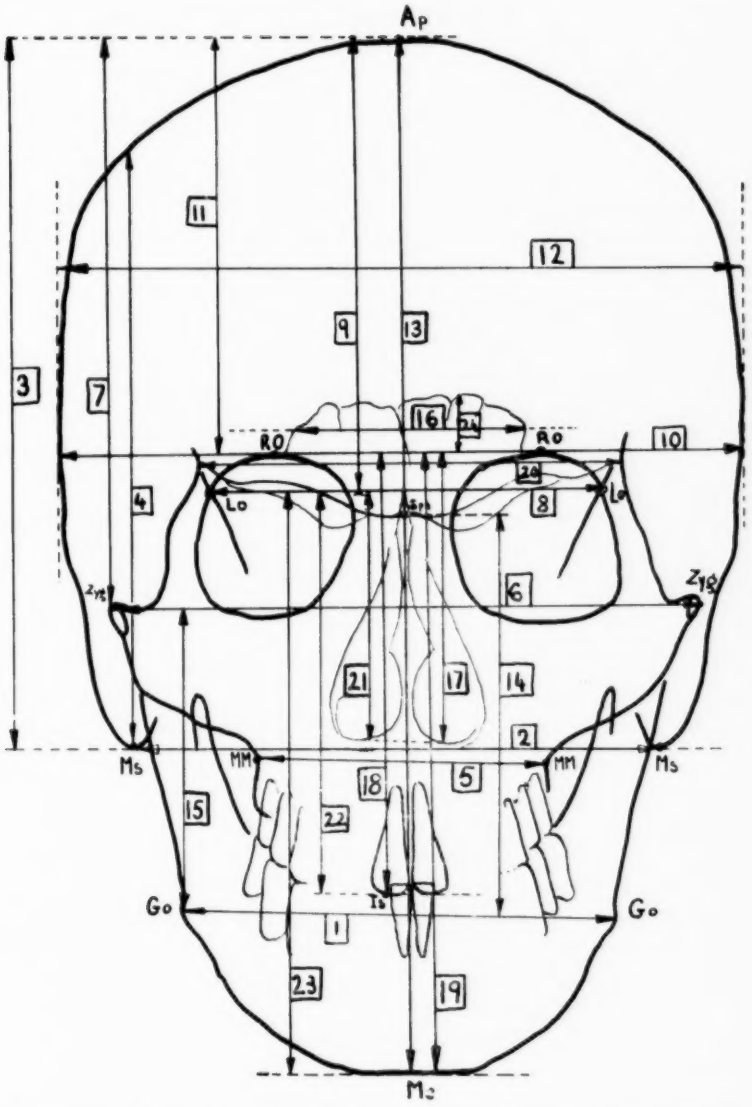


Fig. 1—Frontal view. Twenty four measurements taken from the postero-anterior X-ray films. The eight selected measurements are: 1 – 3 – 5 – 6 – 12 – 16 – 18 – 19.

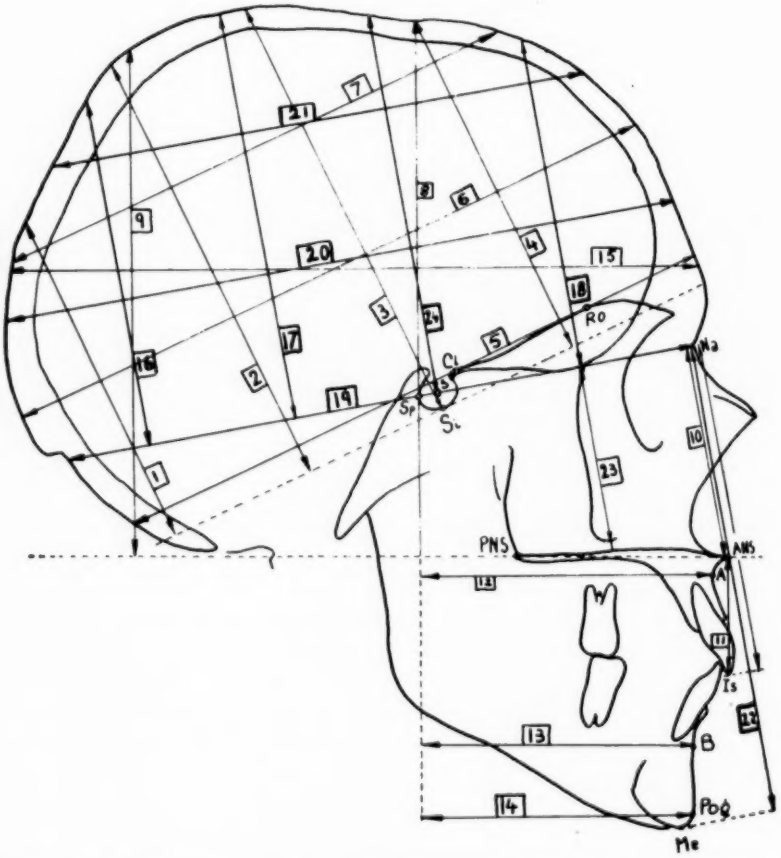


Fig. 2—Lateral view. Twenty four measurements taken from the lateral X-ray films. The eight selected measurements are: 16 – 17 – 18 – 19 – 20 – 21 – 22 – 24.

selectivity $S = \frac{S.D.}{E.} - h\left[\left(\frac{S.D.}{E.}\right) - 1\right]$, was calculated for each measurement and the smallest eliminated. Then, the communalities and the new indices of selectivity were calculated again; the smallest S was eliminated and so on, until only five measurements were left. These are:

1. length of cranium 4 cm. above Na–S,
2. total facial height,
3. sinus breadth,
4. bigonial breadth, and
5. bizygomatic breadth.

It can be observed that among these five measurements, the first one is taken from the lateral film, while the other four are from the postero-anterior film. For reasons of economy (time and material) it was decided to attempt the use of the postero-anterior film only, since the import from the lateral film was only one measurement. All eight frontal measurements were thus finally adopted.

A test of identification was conducted. These eight measurements were taken on 500 AM films and through proper coding were put on a Univac tape. One hundred films were selected at random from the 500 PM films. The same eight distances were measured and, one by one, tests of identification tried on a Univac machine. In seventy-four tests out of 100, one answer, the right one was obtained. The remaining twenty-six contained some error of measurement either on the AM or the PM series. A cross-checking method was developed in order to locate and to neutralize the error. Twenty-three out of 26 were thus identified. This brings the total to 97% identification. The three remaining films could either be identified by further cross-checking or by leaving them until all are identified and by direct comparison of the remaining films. It can be stated, therefore, that 100% identification is achieved through the method proposed here.

According to the index of selectivity and the number of measurements, the actual and theoretical selection was estimated. With twenty measurements and with an index of selectivity of three each, one individual can be identified out of three and one-half billion subjects.

Some improvements have been envisioned in order to perfect this method. The error of measurements proposed can be reduced by increasing the size of the picture, by standardizing the equipment, and by the training of the technicians. A portable unit is proposed which might be used in the field. The sinus area offers still further possibilities with improved techniques. Further researches are warranted here. It is also

recommended that, if the present project is adopted, as an additional parallel study, lateral films also be taken in order to enable the assessment of the growth of the head after twenty years of age, if there be any.

## Conclusions

Although centered around a specific problem, this study covers a much wider scope. In the first place, roentgenographic cephalometry is an accurate tool which permits unknown remains of war-dead to be identified with 100% accuracy. In a more general sense, the present study represents a contribution to the methodology of investigations based on roentgenographic cephalometry, which is one of the best approaches in the study of the physical growth and development of the living.

Researches that are conducted on groups are aimed ultimately at giving more information pertaining or applicable to the individual. In this sense, the present study, highly correlated on the physical characteristics of the head and face, finds its place in the mosaic of investigations conducted for ages around a fascinating central focus: the individuality of human beings. In medical and dental sciences, in anthropology, in such specialties as orthodontics, pediatrics, genetics, prosthetics, geriatrics, in studies on evolution, racial comparisons, etc., the study of individuality is given a central spotlight. The knowledge of the most characteristic measurements representing the individual entity of each person can be applied from this point on for many new investigations.

## Summary

The problem raised by the Quartermaster Research and Development Command, United States Army, was: "What are the five measurements in the head and face (as seen in the postero-anterior and lateral X-ray films) which are the most variable, the least correlated, and the most reliable, that can be used for identification purposes? The mandible should not be included in more than one measurement. The test should be carried out on 500 adult males above eighteen years of age."

This study was conducted at the Philadelphia Center for Research in Child Growth.

1. Four hundred and ninety-eight males were X-rayed twice with the Broadbent-Bolton roentgenographic cephalometer; the first set represents the ante-mortem films (AM) and the second set the post-mortem films (PM). Two hundred and forty-eight were X-rayed in Philadelphia; seventy at the Bolton Fund, Western Reserve University; one hundred and twenty at the University of Illinois; and one hundred and ten at the National Institute of Health. They represent grossly a cross-section of young adult American males.

2. For various reasons but basically in order to obtain the greatest variability for the minimum error, and, at the same time, to avoid tracings, linear dimensions were selected as the method of measurement.

3. Twenty-four measurements were selected on the postero-anterior film. Large error, low variations, and duplications eliminated sixteen of them. The eight selected measurements are: frontal sinus breadth, facial height, bigonial, cranial height (mastoid-apex), incision height, bizygomatic, bimaxillary, and maximum cranial breadth.

4. Twenty-four measurements were selected on the lateral film. By a similar process as for the postero-anterior film 16 measurements were eliminated. The eight selected measurements are: height of the cranium 8 cm. posterior, 4 cm. posterior, just above, and 4 cm. anterior to center of the sella turcica; facial height (Na-Me); cranial length along Nasion-Sella, 4 cm. above, and 8 cm. above.

5. A table of correlation was computed among the sixteen selected measurements (eight postero-anterior, eight laterals). From these sixteen, the five best measurements (in terms of high variability, low error, and low correlation) were selected by individual simultaneous computation. These five measurements are: length of cranium 4 cm. above Na-S, sinus breadth, total facial height, bigonial and bizygomatic breadths. They are the most characteristic of the individuality of an adult male.

6. Since four of the five selected measurements are from the frontal film, and in order to realize a 50% economy, an

attempt was made to use only the postero-anterior film for purposes of identification.

7. A test was made to identify one hundred post-mortem films from 498 ante-mortem films. A special routine was written to permit the location and the neutralization of accidental errors. The test was conducted on a Univac machine. It took ten seconds for the Univac machine to locate the correct film out of 498 possibilities. Direct identification was made on 97%; 3% could be identified by direct comparison with the remaining films. It can be stated, therefore, that the test of identification was 100% successful.

8. Suggestions were made which, if adopted, may lead to: increasing the standardization of the entire process; decreasing the errors; creating a mobile roentgenographic unit; initiating a longitudinal study of the growth of head and face in adults.

9. In conclusion, identification can be realized with 100% accuracy. At the same time, the roentgenographic films gathered will constitute for medical and dental health units an invaluable source of information on one of the most vital areas of the human body.

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626 South 54th Street
Philadelphia 43, Pennsylvania

# Recent Developments in the Use of Infrared Image Converters*

*Richard J. Kuhn, A.B., Silver Spring, Maryland*

The recent interest in the use of electronic image converters in the scientific crime detection laboratory and, particularly, in the document laboratory has produced a number of instruments different from the one originally described some time ago (1).

Probably the simplest instrument is the one used at the Oakland, California crime detection laboratory (2). It consists of an image converter tube type CV 147 housed in a flashlight case and powered by a neon sign high voltage transformer. The most complex instrument described in the literature is one used in infrared microscopy (3).

Within the last year the army sniperscope used during World War II has become available on the surplus market. This instrument is a telescopelike affair that mounts on the barrel of a rifle. It is equipped with a power supply consisting of a 6 volt wet cell battery and a high voltage unit. The telescope houses an image tube, RCA type 1P25, and an objective and ocular lens system. In addition, an infrared light source is included which consists of a 6 v. lamp mounted in a reflector and covered with an infrared filter. Power for its operation is obtained from the 6 v. battery also.

A number of these sniperscopes have been converted for laboratory use by modifying the objective lens system to provide for closer focusing than that provided for in the original instrument. In some of these modified instruments

* Presented at the Ninth Annual Meeting of the American Academy of Forensic Sciences, March 1, 1957, Chicago, Illinois.

the power supply has also been modified to permit power to be taken from the 110 volt mains.

The sniperscope as manufactured can be focused from about three feet to infinity. In order to view objects closer than three feet the objective lens system must be modified. This can be easily accomplished in either of two ways. First, the lens system can be moved farther away from the image tube by the addition of a threaded metal collar used as a spacer, the size of the spacer being selected according to the viewing distance desired. Second, an auxiliary lens can be mounted on the end of the objective lens in a manner similar to the mounting of a portrait lens on a camera. The size of auxiliary lens required may be determined in the following manner:

> The focal length of the sniperscope objective lens system has been determined to be 2 inches (4). A supplementary lens attached to the objective lens when it is focused on infinity will focus the system on a plane whose distance from the system is equal to the focal length of the supplementary lens.
>
> The magnification of the entire system can be calculated from the formula: Mag. $= \frac{u\text{-}f}{f}$, where u = object distance and f = the focal length of the combined system. The focal length of the combined system is equal to $\frac{1}{f_1} + \frac{1}{f_2}$, where $f_1$ is the focal length of the sniperscope objective lens system and $f_2$ is the focal length of the supplementary lens.

As previously noted power to operate the instrument can be obtained from a 6 volt battery. The image tube has extremely low current requirements so the drain on the battery is quite small and the unit can be operated from a dry cell. However, if the light source is to receive its power from the battery also then a wet cell which can be recharged regularly should be used.

If it is desired to operate the instrument from the 110 volt mains an ordinary commercial "battery eliminator" can be substituted for the battery. This is a unit that plugs into the electrical outlet and supplies 6 volts d.c. The price varies according to the number of watts of power the unit is expected to deliver. In the case of low current requirements the price is quite reasonable.

Another way to provide 6 volt direct current from the 110 volt a.c. line is to build a simple power source utilizing a selenium rectifier. This can be done quite simply and cheaply in almost any police laboratory or could be done by any radio or TV repair shop.

All three types of power sources have been used with success. The United States Treasury Dept. Laboratory used a rechargeable battery. The Post Office Dept. Laboratory used a battery eliminator and the Veterans Administration used a selenium rectifier constructed in the laboratory.

There are one or two disadvantages inherent in the use of the 1P25 image tube. The image produced by this tube is slightly smaller than that produced by the CV 147. In addition, the 1P25 requires a number of different voltages for proper operation. A potential of 4,250 volts is required for the photocathode of the tube, one electrode requires voltages varying from 185 to 835 volts, another electrode requires 100 volts and still another electrode requires 20 volts operating potential. As a result of the voltages needed to operate the tube a rather complicated power supply is required. Such a power supply does come with the sniperscope available on the surplus market. However, servicing and maintenance of the unit does present a problem. Figure 1 shows the electrical circuit of the sniperscope power supply.

The CV 147 image tube requires a single voltage of from 2000 to 4000 volts d.c. It is a relatively simple matter to build or buy such a supply which can be either battery operated or operated from the 110 volt a.c. line and which can be repaired or serviced with little or no difficulty. With the CV 147 image tube the sharpness and brightness of the image is in proportion to the voltage placed on the photocathode. In the first instrument built a potential of 1800 volts was pro-

vided for operation of the tube. It has been noted elsewhere (5) and we have found too that the CV 147 tube will operate on voltages up to 6000, but it has also been observed that many of the tubes have a very short life at this voltage. Four thousand volts appears to be the optimum potential for operation of the tube.

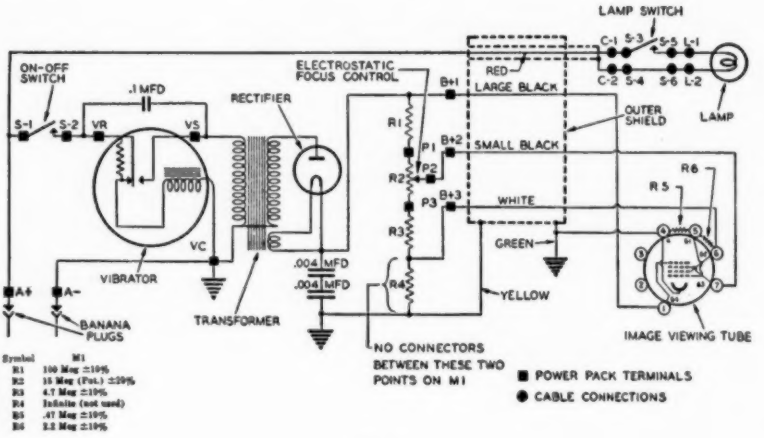


Fig. 1

The best instrument constructed so far is one utilizing the CV 147 tube operated at a potential of 4000 volts and furnished with the optical system of the Army sniperscope.

Advertisements for the sale of surplus Army sniperscopes can be found in such magazines as Radio and Television News and Radio Electronics. The instruments are priced at about $150 each. However, the optical system with which they are equipped is an exceptionally fine one and the instrument is well worth the price. Included is a multielement objective lens system, a very efficient infrared filter made of optical glass, and eyepiece assembly including a rubber eyepiece. Figure 2 is an exploded view of the telescope unit. All of these items can be used to build an instrument specifically adapted for use in examining questioned documents.

In building the modified instrument a short piece of insulated metal tubing can be used to house the CV 147 image

tube. If the ends of this tube are threaded they can then be fitted with adaptors and the sniperscope objective and eyepiece lens systems can be attached. The new instrument can then be fastened to a suitable mount, preferably a rack and pinion focusing mount attached to a heavy base. The 4000

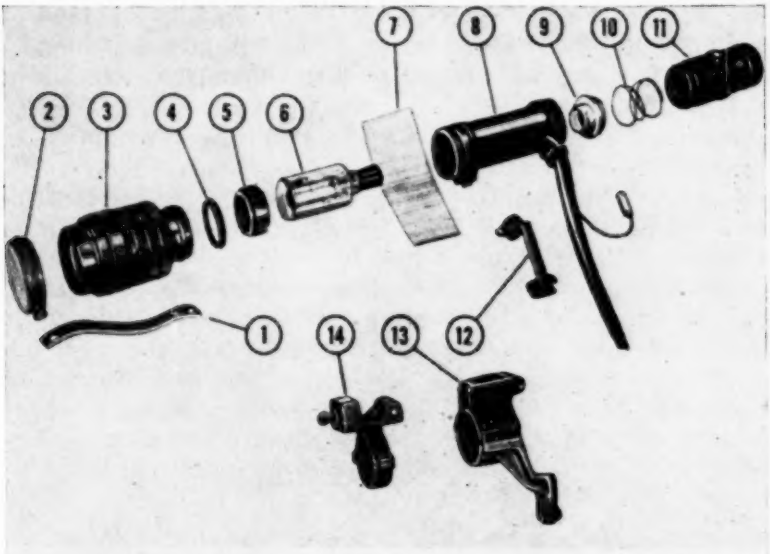


Fig. 2

volts needed to operate the image tube can be obtained in a variety of ways. If portability is desired a battery and vibrater low current high voltage supply can be constructed. If it is desired to operate the unit from the usual 110 volt line then a supply similar to the high voltage supply used to operate a cathode ray tube can be constructed.

There are two other techniques for observing objects in the infrared which do not appear to have much application at

this time but which may prove of future use. One is the use of the Evaporagraph, manufactured by Baird Associates. This is a thermal imaging device operating on radiation differences. It is composed of a very thin nitrocellulose membrane that reflects white light as a color, similar to the effect of oil on water. This membrane is housed in an evacuated cell between an optical system and a viewing system. The back part of this cell is heated slightly, and contains an oil which can be condensed at will upon the rear side of the membrane. The optical system gathers infrared radiation from the field of view and forms an image of the field on the membrane. A special coating on the front surface of the membrane absorbs this radiation and changes temperature from point to point, depending on the amount of radiation received.

These point to point temperature variations alter the thickness of the oil film being condensed on the rear side of the membrane and temperature differences are resolved into differences in oil thickness. These thickness variations cause white light to be reflected as different colors, giving a visible, colored image of the entire field of view. The colors have no relation to the visible colors of the object, but are interference colors and refer only to temperature.

This device is quite sensitive and may prove to be of value in infrared examinations and of interest to the criminalist and document analyst. However, at the present time the machine is still in a development stage and no intensive research into its application in the field of questioned documents has been done.

Another technique that is of interest is the use of the Thermo-Fax machine. This is an office machine used to make rapid copies of typewritten letters and other material. The underlying principle of operation is based on the fact that carbon and some other substances when irradiated with short wave length infrared light reemit the infrared at a higher wave length. This higher wave length infrared is in the region of heat.

A specially prepared paper is used in conjunction with the machine.

The document to be copied and the treated paper are placed together and run through the machine where they are radiated with short wave length infrared light.

This technique often works in reading through obliterated writing and sometimes in reading very faint writing, but it is not sensitive enough to restore erased writing. The value of the machine lies in the fact that it is available in many offices and that a document can be processed in about seven seconds. As long as the copies are not exposed to heat they are permanent.

For the reasons mentioned, neither the Evaporagraph nor the Thermo-Fax machine are suitable at this time for the routine examination of questioned documents in the infrared. The electronic infrared image converter remains the only non-photographic method for the rapid examination of questioned documents in the infrared.

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12808 Crisfield Road
Silver Spring, Maryland

# Personal and Personality Characteristics in Anonymous Letters*

*James V. P. Conway, San Francisco, Calif.*

American document examiners have quite properly concentrated their activities on the so-called physical aspects of documents and document problems. The physical aspects of documents are commonly construed to include the proof of authentic documents, the detection of forged documents and the identification and evaluation of handwriting, typewriting, writing materials, writing instruments and all manner of physical and mechanical markings and impressions on documents. Document examiners in this country have shunned, also I believe advisedly, the nebulous reaches of graphology, the so-called delineation of character from one's handwriting. However, in their proper concentration on the physical elements of document questions and perhaps somewhat because of their aversion to anything that even faintly smacks of graphology, some document specialists have become virtual non-participants in another vital and highly productive area of document examinations; namely, analysis of the objectives and thought content which documents embody.

While this presentation deals particularly with anonymous letters, the purposes and thought content of the entire gamut of evidential documents from the lone forged check to the multiple letter series merits the serious attention of the document examiner and the investigator of documents. The premature comparator of documents, handwritings, inks and

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papers is too much in evidence. Even the single questioned signature should be routinely interpreted for evidences of camouflage and deception, as a prerequisite of further study and the ultimate comparison with other signatures. Was one's purpose merely to write his signature? Was his purpose to conceal his authorship? Or perhaps was his object to adopt the writing personality of another? In extended writings, such as anonymous letters, more complex considerations must be applied as well. What is the underlying objective of the anonymous expressions? What is their basic thought content? What personal descriptive data do the letters provide concerning their author? A careful evaluation of documents and series of interrelated documents, to include the consideration of their underlying thought content, should precede comparisons with other document units and groups of documents. The former action will obviate the necessity for the latter in many cases. In others it will channel investigative effort to the certain detection of elusive authors.

An illustration of the identifying revelations which are adducible from the thought content of documents was forcefully provided in the investigation of a recent series of aggravated anonymous letters and anonymous telephone calls. The prolific author of several hundred obscene and poison pen letters and hundreds of companion anonymous telephone calls was isolated and definitely identified, primarily as the result of the correct interpretation of the thought content of her anonymous missives. This successful case solution was accomplished in a few days and it holds comparative significance because the culprit-author had eluded detection for almost two years, during which period a variety of other methods—typewriting examinations, polygraph examinations, physical searches, extensive questioning of possible suspects and interested principals, etc.,—was unsuccessfully employed by a number of different agencies.

**Case Background**

The locale of this anonymous letter activity was a renowned university city on the West Coast. The letters, all typewritten, or composed of printed cut-outs revolved about the city's school district. This district includes some twenty-five or

thirty elementary, junior high and high schools and encompasses over seven hundred employees. Administration of the district is implemented by a superintendent and central staff, consisting of some sixty education specialists, teacher-consultants, librarians, administrative and clerical personnel.

The principal characters in this case were Mrs. A, teacher-consultant in charge of the Speech Department of the central staff; Mrs. B, her clerk-stenographer, and Mrs. T, a clerk-stenographer, assigned to another department of the central staff. Mrs. T had a ten-year-old son, Jimmy, with a particularly aggravated speech defect. Jimmy was undergoing speech therapy from Mrs. A. Mesdames A, B, and T were friends and frequently in each other's company.

In April 1954 the first anonymous letter was received by Mrs. B. This letter said, in substance, "Why don't you quit your job with the school district?" Several additional letters of the same tenor were received by Mrs. B in the spring of 1954. These letters inferred also that Mrs. A wished to dispense with the services of Mrs. B. No letters were mailed during the school vacation period in the summer of 1954. In the fall of 1954, Mrs. B received several additional letters, the ostensible object of which continued to be to drive her away from her employment in the Speech Department of the school district. At the same time, Mrs. A received two or three letters criticizing her supervision of Mrs. B. During the fall of 1954, Mrs. A received the first of many letters, highly critical and condemnatory of her efforts to solve the speech difficulties of Jimmy T. Mrs. T reported that in the fall of 1954, she received several letters stating that Jimmy would never learn to speak properly and decrying the speech therapy of Mrs. A.

The objectionable nature of the letters was augmented in December 1954. Their tenor became vile and lewd. Mrs. A and Mrs. B were referred to in disgusting and revolting terms and accused of lewd conduct. There was widespread discussion in the offices of the central staff concerning the letters and speculation concerning their possible author. One of the male teachers in the Speech Department came under suspicion as a result of professional differences of viewpoint

concerning the operation of the Speech Department. The possible responsibility of this individual was openly discussed and participated in by Mrs. A, Mrs. B, Mrs. T and many others in the school district, including the superintendent and his immediate staff.

In January 1955, the volume of letters and the objectionable character of their contents grew progressively. Fourteen letters were received in January, fourteen in February, and twenty during March. Some comment appeared in the press about April 1955, as the letters had formally come to the attention of the Board of Education in view of their demoralizing effect on the central staff in general and the three principals in particular. Twelve letters were thereafter circulated in April and six during the first half of May of 1955.

The local police department and the district attorney had been importuned to investigate and they conducted inquiries early in 1955. A private consultant in criminalistics was engaged by the school district in the spring of 1955. The activities of the police department and the district attorney were thereupon terminated. The criminalist examined the available letters, conducted typewriter examinations, interviewed the principals and others, and employed a polygraph operator. Numerous employees of the central staff, including the superintendent, Mrs. A, Mrs. B, and Mrs. T were subjected to one or more polygraph examinations.

It became commonly known that all of the letters to May 1955 had been prepared on an L. C. Smith typewriter. The make of typewriter, the manner and times of mailing and all facets of the letters became subjects of gossip, rumor, suspicion and unrest in the central staff offices.

The summer vacation of 1955 marked the second cessation of the letters. None was mailed between May 15 and August 26, 1955. On August 27, 1955, a death threat was mailed to Mrs. A consisting of a composition of printed cut-outs. The address for this threatening message of August 27, 1955, was typewritten on a second typewriter. When the school year resumed in September the poison pen accelerated her activities. The letters beginning in that month and thence to the apprehension of their author were prepared on a third typewriter, a

Corona portable. The intelligence that the L. C. Smith typewriter had been superseded by a Corona model came within the knowledge of many in the offices of the central staff.

In September 1955, six letters were mailed, twelve in October, four in November, and eighteen in December. Through 1955, the addressees to a large extent had been confined to Mrs. A, Mrs. B, and Mrs. T, although the superintendent and five or six education specialists had received letters. In these excursions beyond the three principal victims, the poison pen seemed to exert especial effort to shock the addressees by lewd language and suggestions.

The anonymous havoc wielder employed envelopes printed with the return address of the school district in large numbers. The names of the superintendent and about ten members of the central staff were shown as the alleged senders of some fifteen or twenty particularly objectionable letters. The letters came to be consistently mailed via special delivery.

The telephone company had become actively interested in the case as hundreds of harassing telephone calls were being made to Mrs. A, Mrs. B, and allegedly Mrs. T. The procedure followed in these nuisances was simply to telephone the number in question and, as soon as an answering voice was heard, to break the connection without an utterance. As many as thirty or forty calls of this sort were interspersed throughout single days. The anonymous caller repeatedly phoned at unseemly early morning hours, although the calls as a whole were not restricted to any portion of the day or night. Even the criminalist became a victim of these calls.

The teacher in the Speech Department who had been originally suspected by many and virtually accused by some had been separated from the district. It was generally accepted at this juncture that he could not have been involved as, following his departure from the area, the letters and telephone calls not only persisted but continued to increase.

Rumors and unrest virtually pervaded the central staff. Suspicions were guarded following recognition of the unjust accusations visited on the initial suspect. However, so many polygraph examinations had been conducted that the "score" which various employees had achieved when subjected to polygraph examination was a not infrequent topic of gossip. A

legitimate indisposition at the time of a polygraph appointment was about enough to bring the indisposed under some suspicion of intentionally avoiding the examination to preclude detection.

In January 1956, the poison pen shifted into high gear. Twenty-three letters were mailed in that month. Beginning in February, the base of operations was further broadened. Some twenty-five or thirty employees of the district, Mrs. A's daughter of junior high school age, the teenage children of Mrs. B, the neighbors of Mrs. B, the young son of Mrs. T, and others were addressed in despicable epistles. A total of fifty-four letters was reported during February. Other letters are known to have been circulated which were not reported. Bizarre obscenity had become the rule rather than the exception. Local arrests involving homosexuality were injected as having a connection to one of the principals and particularly abhorrent messages were directed to the various teenage victims. Mesdames A, B, and T, among others, were showing the ravages of the continued pressure. Every ring of the telephone, every visit of the special delivery messenger, every round of the postman became the agency of mounting tension.

A few of the letters had not confined their vicious content to the enclosures alone, but embodied scurrilous references in their addresses. This circumstance brought the case to the attention of the Postal Inspection Service. Section 1718 of Title 18 of the United States Code prohibits libelous, scurrilous, defamatory, and threatening references on the outside envelope or wrapper of mail matter or on postal cards. Preliminary postal investigation was initiated in October 1955 when it was observed that such prohibited statements were incorporated in the addresses of letters directed to the three principals. These inquiries served to apprise the Postal Inspection Service of the numerous prior and current letters violating Section 1461 of Title 18 of the United States Code which prohibits obscene, lewd, lascivious, and filthy material in the United States mails of any class.

An effort was thereupon made by the Postal Inspection Service to assemble all the communications of the series from the various instrumentalities which had been conducting in-

vestigations, in order that a coordinated analytical survey might be made of the entire series itself, and in the light of the known facts surrounding the principal and other victims. Ultimately, early in March 1956, over two hundred letters were assembled in the San Francisco Identification Laboratory of the Postal Inspection Service for analysis.

**Analysis of Letters**

It was disclosed that approximately 30% of the letters were directed to Mrs. A or members of her family, approximately 30% were addressed to Mrs. T or members of her family, approximately 25% were sent to Mrs. B or members of her family, and the remaining 15% were scattered among some thirty officials, teachers, and employees of the school district and neighbors of Mrs. B.

This examiner has no pretensions of invading the field of psychiatry. However, it is his firm observation from studies of thousands of anonymous letters that the persistent poison pen and obscene letter circulator is a disturbed personality driven by neurotic compulsions to this abnormal mode of expression. In this examiner's view, the keys to the identification of these disturbed personalities lie first in their personal and personality characteristics as expressed within their abnormal missives. In this case, the background, purposes, thought content and personal reflections could mirror only the anonymous culprit from among the various employees of the school district. The prime effort in this Laboratory was, therefore, to describe the personal and personality characteristics of the poison pen and the mechanics and media of the preparation and transmission of the letters.

The following inferences were developed:

(1) The poison pen was a woman.
(2) She had a limited education, was a poor speller, and was authentically non-facile in expression. She was a mediocre touch system typist. Her handwriting was known to the victims.
(3) She resented Jimmy T because of his defective speech.
(4) She resented Mrs. A because of unsuccessful treatment of Jimmy T.

(5) She was envious and jealous of the superior capabilities, personal situations, and happy family circumstances of Mrs. A and Mrs. B—yet craved their association.
(6) She was frustrated, and did not enjoy an active, normal wife-husband relationship. The adoption of a phallic role was evident.
(7) She was in the inner circle of victims, derived satisfaction and a feeling of superiority from the havoc resulting from the letters and telephone calls, and took delight in the prior unsuccessful investigative efforts.
(8) She had substantially uninterrupted control of her time, telephone and a "home" or otherwise readily accessible Corona portable typewriter, equipped with a ribbon having contrasting worn and unworn sections. (This was ultimately determined to be a combination of two ribbons, one fairly new and one virtually worn out.)
(9) She used an automobile to transport the letters to post office buildings rather than street collection boxes.
(10) She had ready access to school district stationery and stamps, including those of denominations up to 20¢.
(11) She grieved over the background and limited capacity of Mrs. T.
(12) She felt pity for Mrs. T in sharp contrast to her feeling toward Mrs. A, Mrs. B, and all other victims.

This presentation will not be belabored with the hundreds of significant words, phrases and thoughts culled from the several hundred letters, but a number of illustrative identifying characteristics will be cited. Respecting (1) above, word choice and word usage were distinctly feminine. Obscenity and references to the genitalia were clumsily, if viciously, handled. A suggestion of primness crept in despite lacings of filth which would curl the hair of a longshoreman.

As to (2), the letters were replete with misuse of possessives, erroneous contractions, actual and feigned misspellings, and evidences of vocabulary limitations. Typing strike-

overs and typing errors relevant to the touch system of typing were patent.

Items (3) and (4) were repeatedly injected, being evident in approximately 40% of the series. Typical thoughts, significantly paired to Mrs. A and Mrs. T, were:

| | |
|---|---|
| 1–14–55 to Mrs. T: | "Don't you know your child will never talk unless he gets the proper therapy?" |
| 1–14–55 to Mrs. A: | "Don't you know Jimmy T will never talk properly with your form of therapy?" |
| 1–30–55 to Mrs. T: | "Don't you know there is no hope for your child. He is better off in an institution." |
| 1–30–55 to Mrs. A: | "Why do you keep on with some of these children when there is no hope. Tell their parents now. They are better off in institutions." |
| 2–20–55 to Mrs. T: | "Haven't you noticed your child's speech slipping back? He will never learn under Mrs. A. He is not very bright anyway." |
| 2–22–55 to Mrs. A: | "Don't you know you will never teach a few to talk. Some are hopeless. Your way of speech therapy is outmoded. Why don't you give up?" |
| 3–3–55 to Mrs. T: | "Don't you know Mrs. A will never teach your dumb child to talk?" |
| 3–8–55 to Mrs. T: | "Don't you know that moron of yours will never talk?" |
| 3–10–55 to Mrs. T: | "Don't you know your imbecile will never talk? Why don't you get him proper treatment? Why doesn't Mrs. A really give him more time?" |
| 3–29–55 to Mrs. A: | "If you don't put Jimmy in a special class, you will harm him. He is a hopeless case." |
| 3–29–55 to Mrs. T: | "Don't you know Jimmy should be in a special class? Haven't you noticed |

him slipping back lately? How come he gets so few speech lessons each week? Mrs. A really doesn't take him very often, does she? You might as well face it, he is a hopeless case."

3–30–55 to Mrs. A: "Your therapy—look at Jimmy T. He is getting farther and farther behind. Put him in a special class."

4–22–55 to Mrs. T: "Well, your babbling moron doesn't talk any better this year than he did last year, does he?"

5–16–55 to Mrs. T: "So you think that moron of yours will still talk? Don't you know that imbecile will never speak clearly?"

5–26–55 to Mrs. T: "Don't you know Mrs. A will never teach your child to talk? You had better find someone else."

3–4–56 to Mrs. A: "What makes you think you can teach anyone. Look at that poor moron of a Jimmy T."

*Singularly, no other student of Mrs. A was ever mentioned, except Jimmy T.*

Respecting (5), all the assertions, without exception, concerning Mrs. A and Mrs. B were uncomplimentary, vile, threatening or lewd. Threats to "break down" Mrs. A and Mrs. B by attacks on their children were made and thereafter carried out. The kindest statements made by the poison pen concerning Mrs. A were that she was "ungracious," "egotistical" and aroused contempt, and Mrs. B was accused of likening herself to "God herself." Threats of bodily harm as well as damage to the reputations of the children of Mrs. B were voiced in numerous letters as the alternative to her refusal to resign from her position.

Item (6) was strikingly evident in the torrent of sexuality which characterized over one hundred of the letters. Somewhat typical were lewd suggestions advanced to a very pretty and very proper staff member, threats of emasculation, and threats of forced sex activity. In these areas, the anonymous author was the suggester, the threatener, the active member.

Noteworthy in a contrasting vein were poetic references to masturbation, the question in a letter to Mrs. T, "Don't you know Mr. A and Mr. B are ready to rape you?" and in another letter to Mrs. T, what was tantamount to a complaint respecting her sexual abstinence followed by an anatomical comparison wherein Mrs. T was favored in direct comparison with Mrs. A and Mrs. B.

Item (7) was reflected variously by statements such as "Aren't we having fun whispering and snickering?" "Wouldn't you like to know who I wrote to this time?" "Getting a little hysterical over the phone calls, aren't you?" and "Isn't it fun Mrs. B seeing them squirm?" It is rather generally known among those who have even a passing acquaintance with the poison pen problem that the author is usually also a "victim." It seems to have been commonly accepted that the practice of a poison pen to include herself on her own mailing list is a strictly defensive maneuver, in order to ward off suspicion. This theory has merit and it deserves careful consideration. However, studies of many anonymous letter series by this examiner disclose a further, if related, basis for this artifice. By becoming a major "victim" herself, the poison pen can invade the inner circle of victims, maintain a first-hand rein on their comments and suspicions, grovel in the general mischief, find soft spots for juicy assertions in future letters, and position herself for planting, routing, and fending off suspicions. As a major victim, the poison pen can, foxlike, join the hounds to chase herself and, with a feeling of gleeful superiority, manufacture misinformation and alibis to confound the letters' investigation. Significant in this light, were several references in the letters to the criminalist, the circumstance that the criminalist was himself victimized by the anonymous calls, and the poison pen's frequent practice of mailing an original letter and identical carbon copies, respectively, to the three principals.

Item (8) followed from the very volume and repetition of the letters and calls itself; (9) followed from the habitual use of special delivery stamps, such use being incompatible with the neutralization of special delivery service by the use of street collection boxes, (10) stemmed from the mass use of

the printed stationery of the school district and large scale usage of stamps of 2¢, 5¢, 10¢ and 20¢ denominations.

Items (11) and (12) were reflected by self-pity, for example:

2–27–55 to Mrs. T: "Just to say that you are remembered with the deepest and most sincere sympathy that words can express."

3–10–55 to Mrs. T: "You poor fool to let her take Jimmy."

3–18–55 to Mrs. T: "With your back ground (sic) your boys will be a failure. Your boys will grow up just like you. I guess you poor soul it is because of your association with prostitutes like Mrs. A and Mrs. B."

3–30–55 to Mrs. A: "Put him in a special class or I will make it hard on Mrs. T with phone calls and letters."

*Mrs. T was the only "poor soul" of the letters.*

**The Principals**

Mrs. A was fortyish, forceful, a recognized authority on speech problems in education, dedicated to her work. Her husband was a popular administrator in an adjoining school district, and their teenage daughter evidenced excellent bearing and high intelligence. Mrs. B, somewhat younger, was quietly competent, comely, a highly efficient clerical assistant. Her husband was a successful attorney, and their teenage son and daughter were handsome, capable children. Prior to the disruption of their lives by these anonymous letters and phone calls, the A and B individual family units were closely knit, and enjoyed superior home atmosphere in distinctly above average living situations.

Mrs. T, a widow, in her early forties, would not be considered attractive and her clerical work on the central staff was considerably less than distinguished. She was not noted for a high order of concentration, precision in expression, orthography, or ability as a typist. Mrs. T was married in

her early twenties to a successful professional man in industry. The union was a happy one and Mrs. T was both devoted to and dependent upon her husband. The couple had two children, the older in his early teens, with perhaps some proclivity to juvenile mischief. The second boy, a handsome little fellow, was born with a cleft palate. Despite extensive therapy by Mrs. A and others, the boy's speech was scarcely intelligible.

Two years prior to the outbreak of these letters, Mrs. T's mother, to whom she was intimately attached, died from natural causes and shortly thereafter her own husband was killed in a motor vehicle collision. The latter produced involved civil litigation which heightened the already severe impact of the tragedy on the widow. Mrs. T's normal sex life terminated with her husband's death and she had no active male interests. Bereft of the support of mother and husband, Mrs. T was faced with stern responsibilities for the first time in her life. Receiving the active assistance of Mrs. A in respect to her major problem involving Jimmy's speech failures, Mrs. T had begun to look to Mrs. A for intellectual support in other day-to-day problems.

## Field Investigation

Even a casual consideration of the persons affected by the anonymous letters and telephone calls revealed with striking clarity that Mrs. T was the one and only individual whose characteristics coincided with the thought content and media of preparation and transmission adducible from the letters.

Several selective interviews were conducted to pinpoint alibi fabrications by Mrs. T. It was known that she had made allegations to all and sundry that she had been constantly harassed by the anonymous phone calls. Mr. and Mrs. A and Mr. and Mrs. B had been together when several calls were received by them. It was anticipated that this circumstance would have induced Mrs. T to have projected false alibis in this respect. Such proved to be the case as it was developed that on several occasions she had cited the names of friends who were purportedly present in her home when the harassing calls were allegedly received by her. Spot checks with

several of these "witnesses" established the falsity of Mrs. T's carefully planted statements.

Mrs. T was placed under surveillance. Arrangements were made for the legitimate victims to record the precise moment the telephone calls in question were received. Mrs. T was observed in the acts of making the familiar calls from public telephones on March 8, 9, 10 and 11, the exact timing of which coincided with the recorded receipt of calls by the legitimate victims.

She was observed to mail three letters on March 8 at a post-office station, such letters being duly received by the legitimate victims on the morning of March 9 in the presence of this examiner and a postal inspector associate. Analysis of the typewriting in these letters disclosed that the same Corona typewriter continued in usage by Mrs. T.

Arrangements were made to supply Mrs. T with premarked stationery and stamps if such action proved necessary. The button area of the door handle of her car, driver's side, was tagged with fluorescent paste. Authorization was obtained from the legitimate victims to seize mail addressed to them, and associated with the series through typewriting comparisons, at any point of postal transit.

On March 11, while under surveillance, Mrs. T mailed at the main post-office building three of the familiar typewritten letters—an original to Mrs. B with identical carbon copies to Mrs. A and to herself. Immediate recovery and examination of these letters disclosed that the same Corona typewriter continued in use and that two of the letters bore fluorescent prints corresponding to the fluorescent paste affixed to Mrs. T's car. During the period when the three letters mailed on March 11 would have been prepared, Mrs. T had visited no location save her own home at which she had adequate opportunity to prepare the letters. Patently, the typewriter was in her home. Further, nobody save Mrs. T had touched the tagged button of her automobile as it had been continuously under observation from the time of tagging. Incidentally, she had placed three of the nuisance calls from a public telephone in the post-office building and three more enroute to her home from her final "mailing."

Mrs. T was promptly placed in custody at her home. She was courteously but firmly informed that it had been definitely determined that she was exclusively responsible for the anonymous letter and telephone call series. She was caused to view under ultraviolet light the fluorescent agent on the door button of her car, on her own thumb, and on two of the three letters she had mailed while under surveillance on March 11. Mrs. T made several rather ludicrous efforts to secrete and destroy the evidence in her home. However, the Corona portable typewriter was promptly located and identified by comparison of its type faces. Carbon paper was found which was determined by transmitted light examination to contain the identical typewriting of prior letters. Similar stationery and stamps were recovered and a number of obscene letters were found which had been prepared but not yet mailed.

## Conclusion

On her apprehension, Mrs. T was initially defiant and intractable. The positive unmasking of her long time anonymity by the coordination of technical and investigative efforts, from which she had been completely excluded and denied any opportunity of "participation," was an unexpected culmination to her masquerade. In despair, during the course of the search of her home, Mrs. T made a determined but unsuccessful effort at self-destruction. She was temporarily hospitalized and preliminarily arraigned on March 12, 1956, on the charge of mailing obscene and filthy matter in the United States mails. Following her initial arraignment, Mrs. T's attitude changed and she acknowledged all the subject letters and telephone calls. She evidenced shame, repentance, relief, gratitude, and bewilderment. She was urged to confide freely in the psychiatrist to be appointed by the Court, as the indispensable first step in her own rehabilitation, and in order that the Court might be properly informed incident to passing judgment on her responsibility. From this point, Mrs. T evidenced cooperation. She ultimately pleaded guilty to a representative violation of 18 USC 1461 and was placed under lengthy probationary supervision with stipulated psychotherapy at her own expense. To this examiner's knowledge, there

has been no recurrence of her anonymous communications or other abnormal conduct.

The techniques of this investigation are cited as typical of many successful anonymous letter case solutions. With its ramifications, this investigation serves to emphasize the value of competent analysis of the personal and personality characteristics of anonymous letters in terms of technical and investigative manpower, the rights of legitimate victims, the public interest, and the treatment of the poison pen herself.

Postal Inspector and
Questioned Document Analyst
San Francisco, California

# A Statistical Study of the Individual Characteristics of Fired Bullets*

*Alfred A. Biasotti, B.A., M.C., San Jose, California*

An almost complete lack of factual and statistical data pertaining to the problem of establishing identity in the field of firearms identification prompted this study to be undertaken. It was hoped that some factual data could be collected to answer the fundamental question of what constitutes an identity or non-identity of a pair of fired bullets. The means selected for obtaining this data was to conduct a direct statistical count of the elements which actually form the basis of the identity; e. g., the individual characteristics. Since only one make and type of gun was studied, the class characteristics are identical and therefore were considered constant for statistical purposes.

The direct visual comparison of the fired bullets with a conventional comparison microscope (Figure 1) employing direct oblique illumination was the means of observation selected because this procedure appeared to conform to current accepted procedure.

The statistical population studied consisted of two groups of .38 Special Smith and Wesson revolvers. The first group consisted of sixteen used guns from which six to twelve 158-grain lead bullets were fired (Table 1). The second group consisted of eight new guns from which six (58-grain lead bullets and six 158-grain metal-cased bullets were fired (Table 2). The data for comparisons made between bullets fired

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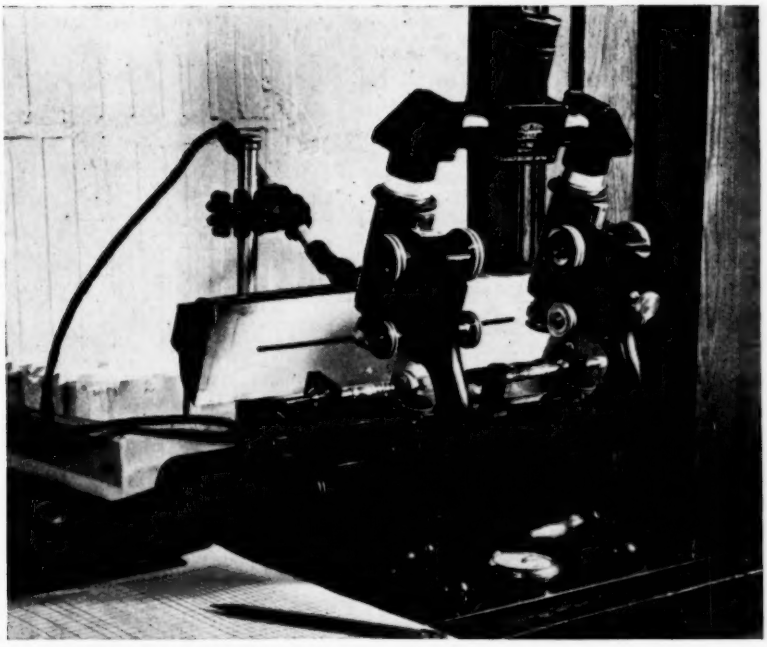

Fig. 1—The comparison microscope and lamp arrangement used in this study. White cards, omitted in photo in order to show bullet holders, were used for back lighting (reflected) each bullet. The lamp is a model MR[4] supplied by Geo. W. Gates & Co., Inc., Long Island, N. Y., and was equipped for this study with a single 8W daylight fluorescent lamp. The improvised mask contains a ¼″ x 9″ slit.

from the same gun was obtained by considering the first bullet as the primary reference or question bullet and then comparing the succeeding five tests with it. Every land and groove mark of the question bullet was compared with every land and groove mark of the succeeding five tests making a total of 400 land and 400 groove marks compared for the group of sixteen used guns, and a total of 200 land 200 groove marks for each group of lead and metal-cased bullets from the eight new guns. The data for bullets fired from different guns was obtained by comparing the first bullet from each gun with the first bullet from a different gun for a total of 36 different combinations, giving a total of 180 land and

180 groove marks compared for each of the following groups of guns and tests: (1) used, lead bullets; (2) new, lead bullets; and (3) new, metal-cased bullets.

TABLE 1

GUNS 2-18---CONDITIONS OF TESTS

| GUN NO. | SERIAL NO. BARREL | SERIAL NO. BUTT | BULLET NO. AND ORIENTATION Q(1) | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 2 | V-521 282 | V-79 702 | 3 | 10 | 6 | 12 | 6 | 10 | 3 | 3 | 9 | 6 | 3 | 6 |
| 3 | V-522 716 | V-75 567 | 9 | 12 | 6 | 9 | 6 | 6 | 6 | 9 | 12 | 3 | 6 | 9 |
| 4 | V-519 202 | V-73 721 | 3 | 6 | 12 | 6 | 3 | 12 | 3 | 6 | 6 | 12 | 3 | 9 |
| 5 | V-523 049 | V-81 415 | 9 | 3 | 12 | 6 | 9 | 3 | 6 | 5 | 12 | 3 | | |
| 6 | V-521 028 | V-75 014 | 3 | 6 | 12 | 3 | 6 | 12 | 6 | 3 | 6 | 12 | 3 | 3 |
| 7 | V-523 053 | V-59 873 | 3 | 9 | 6 | 12 | 6 | 12 | | | | | | |
| 8 | V-525 224 | V-81 640 | 6 | 12 | 3 | 6 | 6 | 12 | | | | | | |
| 9 | V-520 770 | V-72 650 | 12 | 6 | 9 | 9 | 6 | 12 | | | | | | |
| | | | RANDOM CHAMBERS | | | | | | | | | | | |

| | | | Q(1) | 2 | 3 | 4 | 5 | 6 | Q(7) | 8 | 9 | 10 | 11 | 12 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 10 | V-524 213 | V-81 832 | 9 | 12 | 3 | 6 | 12 | 9 | 3 | 6 | 3 | 9 | 12 | 6 |
| 11 | V-524 185 | V-79 257 | 3 | 6 | 3 | 12 | 9 | 6 | 9 | 3 | 12 | 6 | 9 | 3 |
| 12 | V-520 829 | V-79 094 | 12 | 9 | 6 | 3 | 12 | 3 | 6 | 6 | 9 | 12 | 3 | 6 |
| 13 | V-520 062 | V-78 327 | 6 | 3 | 6 | 9 | 12 | 3 | 9 | 12 | 6 | 6 | 9 | 12 |
| 14* | V-527 190 | V-82 697 | 3 | 6 | 12 | 3 | 6 | 12 | 1 | 2 | 3 | 4 | 5 | 6 |
| 15 | V-516 135 | V-75 017 | 12 | 3 | 9 | 6 | 12 | 6 | CONSECUTIVE CHAMBERS | | | | | |
| 16 | V-526 624 | V-71 565 | 9 | 12 | 9 | 3 | 6 | 12 | | | | | | |
| 17 | V-518 596 | V-74 798 | 3 | 3 | 12 | 12 | 3 | 3 | | | | | | |
| 18 | V-519 834 | V-74 174 | 6 | 3 | 9 | 6 | 12 | 3 | | | | | | |
| | | | CONSTANT CHAMBERS | | | | | | | | | | | |

* Test bullets from Gun 14 not used for statistical calculations because of severe striping and gas cutting.

NOTES

GUNS: 38 Spl. REVOLVERS, SMITH & WESSON, MILITARY & POLICE, VICTORY MODEL.

RIFLING: (Mfg. specifications) Bore diam. (0.3555 to 0.3572"); five lands, width (0.1034") and grooves, width (0.1140") with right hand twist (1 turn in 18 3/4"). Rifled with a hook cutter and lead lapped. Manufactured in 1941. See Appendix, Table I, for measurement of land widths.

WEAR: All guns showed signs of extensive use and wear.

AMMUNITION: 38 Spl. REMINGTON KLEANBORE, POLICE SERVICE, 158 GR LEAD (5158)

COLLECTING MEDIA: Long staple cotton

CLEANING: Cleaned before first shot only except guns 10-13, bullets 7-12, which were cleaned before each test shot.

DATE OF FIRING: Guns 2-9, March 1951; guns 10-18, July 1951.

A restricted population of one common type of gun rather than a broad cross section of all possible guns was chosen for study to minimize the size of the statistical sample and also to reduce the number of experimental variables. The reasons for selecting the particular type of gun used are as follows: (1) availability; (2) quality; (3) both lead and metal-cased bullets could be fired; and (4) the nearly equal land groove width.

Since it was decided to record all of the individual characteristics for all of the bullets compared, the data sheet shown in Figure 2 was designed to aid in both the initial recording and subsequent tabulation of the data for statistical purposes. The nomenclature and orientation relating the bullet to the data sheet is shown in Figure 3.

For this study the word "lines" is used as synonymous with engraving or striation to facilitate writing because of its frequent use. A line is defined as an engraving or striation appearing on the bullet as the result of being engraved by the individual irregularities or characteristics of the barrel, plus any foreign material present in the barrel capable of engraving the bullet. Two lines are defined as matching lines when they appear to coincide according to the following criteria: (1) When the bullets are in phase; (2) when their angle lies between the long axis of the bullet and the angle of twist; and (3) when the lines appear to be similar in contour and of common origin. The matched or the in-phase position was determined for each pair of bullets with the aid of orientation marks placed on the bullets as they were placed in the cylinder for firing (Tables 1 and 2).

Two basic types of data were recorded: (1) The total line count and total matching lines per land or groove mark from which the percent matching lines were derived (Tables 3 and 4); and (2) the frequency of occurrence of each series of consecutive matching lines for which probability estimates were calculated (Figures 4 to 8).

Dealing first with the data for percent matching lines given by Tables 3 and 4, it will be seen that the average percent match for bullets fired from the same gun ranged from 36 to 38% for lead bullets and from 21 to 24% for metal-cased bullets. For bullets fired from different guns (not tabulated)

15 to 20% matching lines per land or groove mark was frequently found. Relatively speaking, this data indicates that even under such ideal conditions the average percent match for bullets from the same gun is low and the percent match for bullets from different guns is high, which should illustrate

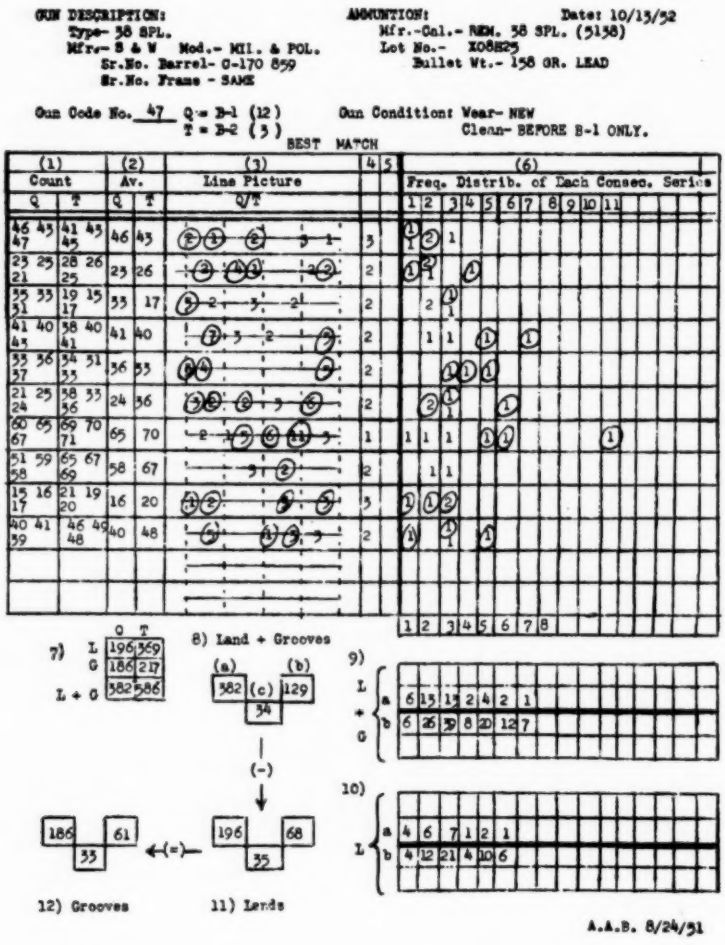


Fig. 2 A completed data sheet for a comparison of two lead bullets fired from the same gun.

the limited value of percent matching lines without regard to consecutiveness. As frequently happens in actual practice, when there is a preponderance of non-matching lines and only

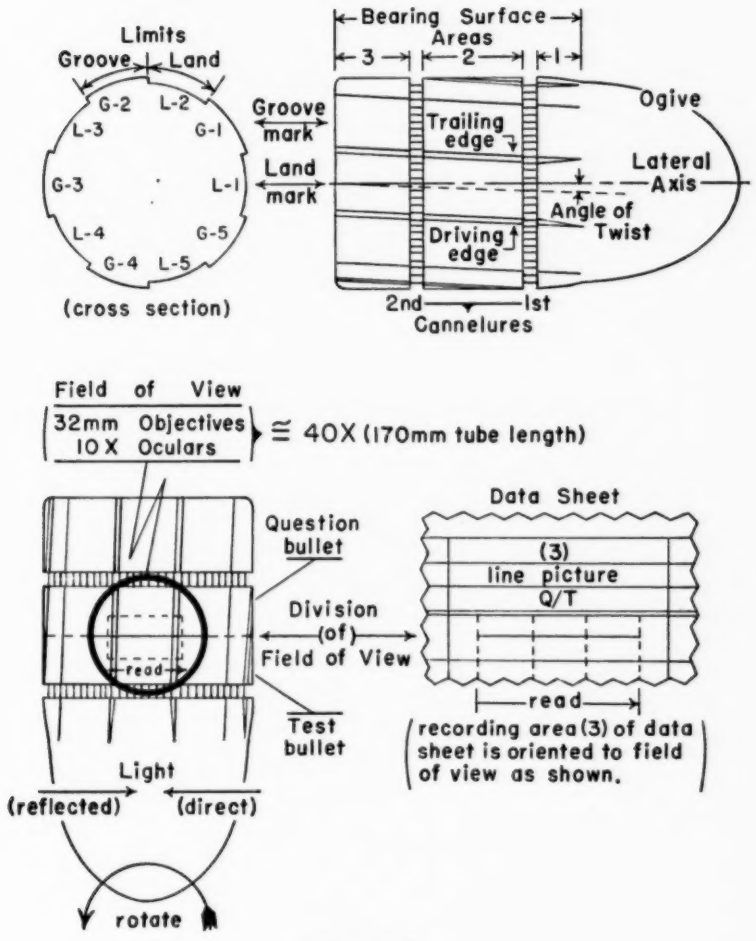


FIGURE 3

AAB53

TABLE 2

GUNS 40-47---CONDITIONS OF TESTS

| GUN NO. | SERIAL NO. BARREL | BULLET NO. AND ORIENTATION — LEAD BULLETS Q(1) | 2 | 3 | 4 | 5 | 6 | METAL CASED BULLETS Q(1) | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 40 | C-176 498 | 3 | 9 | 6 | 6 | 9 | 6 | 6 | 12 | 6 | 3 | 9 | 3 |
| 41 | C-173 209 | 9 | 12 | 3 | 6 | 9 | 3 | 12 | 6 | 3 | 9 | 6 | 12 |
| 42 | C-172 131 | 12 | 6 | 3 | 9 | 6 | 12 | 3 | 9 | 6 | 12 | 6 | 3 |
| 43 | C-176 826 | 6 | 12 | 9 | 9 | 6 | 12 | 9 | 6 | 3 | 12 | 6 | 6 |
| 44 | C-178 156 | 6 | 5 | 12 | 9 | 6 | 3 | 3 | 6 | 12 | 6 | 6 | 6 |
| 45 | C-174 010 | 9 | 6 | 3 | 6 | 6 | 9 | 12 | 6 | 9 | 9 | 6 | 3 |
| 46 | C-175 000 | 3 | 6 | 6 | 3 | 12 | 3 | 9 | 3 | 12 | 6 | 9 | 3 |
| 47 | C-170 859 | 12 | 3 | 6 | 9 | 3 | 12 | 6 | 12 | 6 | 9 | 6 | 12 |
| | | CONSTANT CHAMBER | | | | | | | | | | | |

NOTES

GUNS: 38 Spl. REVOLVERS, SMITH & WESSON, MILITARY & POLICE, COMMERCIAL GRADE.

RIFLING: Same as for guns 2-18 except that guns 40-47 were rifled with a broach cutter and lead lapped. Manufactured in 1951. See Appendix, Table II for measurement of land widths.

WEAR: All these guns were new, as received from the manufacturer, and had not been issued for service prior to firing the above tests.

AMMUNITION:
LEAD: Same as for guns 2-18
METAL CASED: 38 Spl. PETERS, 158 GR. M.C. (Government Contract, July '51)

COLLECTING MEDIA: Long staple cotton

CLEANING: Before first shot only in each series, lead bullets followed by metal cased bullets.

DATE OF FIRING: October 1951

a few land and groove marks available for comparison, the total number of matching lines is often no higher or even less than the number which could occur as the result of chance.

A similar statistical study of tool marks by Burd and Kirk (2) reported as few as 80% matching lines for tool marks

TABLE 3

| TOTAL AVERAGE LINE COUNT, MATCHING LINES & PERCENT MATCHING LINES PER MARK | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| TOTAL AVERAGE per LAND or GROOVE MARK $\left[PM(\%) = \frac{ML}{LC}(100)\right]$ | | | GUNS 2-18*, USED LEAD BULLETS | | | | | | GUNS 2-18* | GUNS 40-47, NEW | |
| | | | RANDOM CHAMBER GUNS 2-9, B(1-6) | | CONSTANT CHAMBER GUNS 10-18, B(1-6) | | CONSECU. CHAMBER GUNS 10-13, B(7-12) | | | LEAD | M.C. |
| | | | | | | | | | | CONSTANT CHAMBER B(1-6) | |
| | | | CENTER MATCH | BEST MATCH | CENTER MATCH | BEST MATCH | CENTER MATCH | BEST MATCH | BEST MATCH | BEST MATCH | |
| (LC) REPEATED (X5) LINE COUNTS for B-1(Q) only | LANDS | $\bar{X}$ | 10.4 | 12 | 14 | 16.5 | 10.8 | 12 | 13.3 | 37 | 88(66)** |
| | | V(%) | (8) | (9) | (9) | (12) | (7) | (10) | (10%) | (17) | (15) |
| | | RANGE | 0-26 | 0-28 | 0-30 | 0-32 | 0-17 | 0-29 | 0-32 | 8-73 | 33-142 |
| | GROOVES | $\bar{X}$ | 15.4 | 15.5 | 17.2 | 17.6 | 17.2 | 17.8 | 17.5 | 42.5 | 86(70)** |
| | | V(%) | (10) | (10) | (9) | (11) | (7) | (8) | (9%) | (15) | (16) |
| | | RANGE | 0-40 | 0-36 | 0-34 | 0-31 | 0-30 | 0-27 | 0-36 | 7-87 | 35-160 |
| (ML) MATCHING LINES | LANDS | $\bar{X}$ | 3.6 | 4.6 | 4.3 | 5.5 | 3.8 | 5.1 | 5.1 | 11 | 21.5 |
| | | V(%) | (24) | (24) | (20) | (21) | (16) | (26) | (24%) | (20) | (16) |
| | | RANGE | 0-10 | 0-11 | 0-11 | 0-20 | 0-8 | 0-14 | 0-20 | 0-34 | 5-44 |
| | GROOVES | $\bar{X}$ | 5.1 | 6.2 | 5.5 | 6.4 | 5.8 | 6 | 6.2 | 14.6 | 18 |
| | | V(%) | (26) | (25) | (29) | (21) | (31) | (22) | (23%) | (19) | (25) |
| | | RANGE | 0-18 | 0-24 | 0-22 | 0-16 | 0-15 | 0-24 | 0-24 | 0-36 | 1-68 |
| (PM) PERCENT MATCH (%) | LANDS | $\bar{X}$(%) | 35 | 38 | 31 | 33 | 35 | 42 | 38% | 30 | 24(33)** |
| | | RANGE | 0-64 | 0-91 | 0-58 | 0-65 | 0-89 | 0-87 | 0-91% | 3-50 | 6-48 |
| | GROOVES | $\bar{X}$(%) | 33 | 40 | 31 | 33 | 34 | 34 | 36% | 34 | 21(26)** |
| | | RANGE | 0-94 | 0-94 | 0-89 | 0-59 | 0-68 | 0-96 | 0-96% | 0-75 | 3-60 |
| n(marks) for LC, ML & PM | | | 200 | 200 | 200 | 200 | 100 | 100 | 500 | 200 | 200 |

*Ibid TABLE I

**Values in parenthesis for first total line count on B-1(Q) only

TABLE 4

TOTAL AVERAGE LINE COUNT, MATCHING LINES & PERCENT MATCHING LINES PER BULLET

| TOTAL AVERAGE per BULLET $\left[PM(\%) = \frac{ML}{LC}(100)\right]$ | | | GUNS 2-18*, USED LEAD BULLETS | | | | | | GUNS 2-18* BEST MATCH | GUNS 40-47, NEW | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | RANDOM CHAMBER GUNS 2-9, B(1-6) | | CONSTANT CHAMBER GUNS 10-18, B(1-6) | | CONSECU. CHAMBER GUNS 10-13, B(7-12) | | | LEAD | N.C. |
| | | | CENTER MATCH | BEST MATCH | CENTER MATCH | BEST MATCH | CENTER MATCH | BEST MATCH | | CONSTANT CHAMBER B(1-6) BEST MATCH | |
| (LC) REPEATED (X5) LINE COUNTS for B-1(Q) only | LANDS | $\bar{X}$ | 52 | 60 | 70 | 83 | 54 | 60 | 68 | 185 | 442(333)** |
| | | V(%) | (8) | (9) | (9) | (12) | (7) | (10) | (10%) | (17) | (15) |
| | | RANGE | 22-80 | 22-86 | 48-122 | 48-122 | 44-66 | 44-82 | 22-122 | 93-265 | 258-610 |
| | GROOVES | $\bar{X}$ | 78 | 77 | 86 | 88 | 85 | 89 | 84 | 213 | 432(352)** |
| | | V(%) | (10) | (10) | (9) | (11) | (7) | (8) | (9%) | (15) | (16) |
| | | RANGE | 39-132 | 39-132 | 51-119 | 51-123 | 67-97 | 67-107 | 39-132 | 149-302 | 263-568 |
| (ML) MATCHING LINES | LANDS | $\bar{X}$ | 18 | 23 | 22 | 28 | 19 | 26 | 26 | 54 | 108 |
| | | V(%) | (24) | (24) | (20) | (21) | (16) | (26) | (24%) | (20) | (16) |
| | | RANGE | 6-35 | 6-27 | 11-40 | 11-42 | 11-26 | 11-41 | 6-42 | 26-97 | 69-173 |
| | GROOVES | $\bar{X}$ | 26 | 31 | 27 | 32 | 28 | 30 | 31 | 73 | 91 |
| | | V(%) | (26) | (25) | (29) | (21) | (31) | (22) | (23%) | (19) | (25) |
| | | RANGE | 4-46 | 10-52 | 3-57 | 3-61 | 13-53 | 13-57 | 3-61 | 35-116 | 37-193 |
| (PM) PERCENT MATCH (%) | LANDS | $\bar{X}$(%) | 35 | 38 | 31 | 33 | 35 | 42 | 38% | 30 | 24(33)** |
| | | RANGE | 9-77 | 9-85 | 14-58 | 14-58 | 22-46 | 22-71 | 9-85% | 14-47 | 16-38 |
| | GROOVES | $\bar{X}$(%) | 33 | 40 | 31 | 33 | 34 | 34 | 36% | 34 | 21(26)** |
| | | RANGE | 14-57 | 14-75 | 4-56 | 4-65 | 14-57 | 14-57 | 4-75% | 16-71 | 7-41 |
| n(bullets) for LC, ML & PM | | | 40 | 40 | 40 | 40 | 20 | 20 | 100 | 40 | 40 |

*Ibid TABLE I

**Values in parenthesis for first total line count on B-1(Q) only

made with the same screwdriver with all of the controllable variables (e.g., vertical and horizontal angle, pressure, and type of material receiving the mark) held constant. Also re-

EXPLANATION OF SYMBOLS AND CALCULATIONS

FOR TABLES 3 AND 4

ARITHMETIC MEAN ($\bar{X}$):

$$\bar{X} = \frac{\sum x}{n}$$

$\bar{X}$ = total average lines, or matching lines per land or groove, or per bullet.

$x$ = individual observations, e.g., total lines, or matching lines observed.

$n$ = total number of lands or grooves, or lands and grooves, giving total $x$.

STANDARD DEVIATION ($s$):

$$s = \sqrt{\frac{\sum (\bar{X} - x)^2}{n}}$$

$\bar{X} - x$ = the deviation of each observed $x$ from $\bar{X}$.

RELATIVE DISPERSION (V%):

$$V\% = \frac{100\ s}{\bar{X}}$$

RANGE: The smallest and largest value observed.

PERCENT MATCH (PM):

$$PM\% = \frac{\text{Total Matching Lines}}{\text{Total Line Count}^*} (100)$$

* The average total line count for five repeated counts on B-1 (Q) made in comparing B (2-6) with the following exception: values in parenthesis given in tables 3 and 4 for metal cased bullets, guns 40-47, are calculated using only the first total line count for B-1 (Q).

ported was a chance occurrence of 20 to 25% matching lines for tool marks made by two different screwdrivers. This data given for tool marks and that reported in this study

for fired bullets should dispel the erroneous conception of the "perfect match" which is actually only a theoretical possibility and a practical impossibility.

Since no two objects are ever absolutely identical, a realizable or practical identity must be based on the occurrence of a sufficiently high number of corresponding individual characteristics having a very low probability of having occurred as the result of chance, and therefore must be the result of a common cause. It should be obvious that consecutiveness; viz., the compounding of a number of individual characteristics, is the very basis of all identities. When individual characteristics are grouped or related by the criteria of consecutiveness, which is a simplified means of expressing a correspondence of contour, the chance occurrence of even a very small number of consecutive matching lines (e.g., more than 3 or 4) is for all practical purposes impossible except as the result of a common agent, e.g., same gun. This concept is substantiated by the probability estimates calculated from the relative frequency of occurrence of the consecutive match-

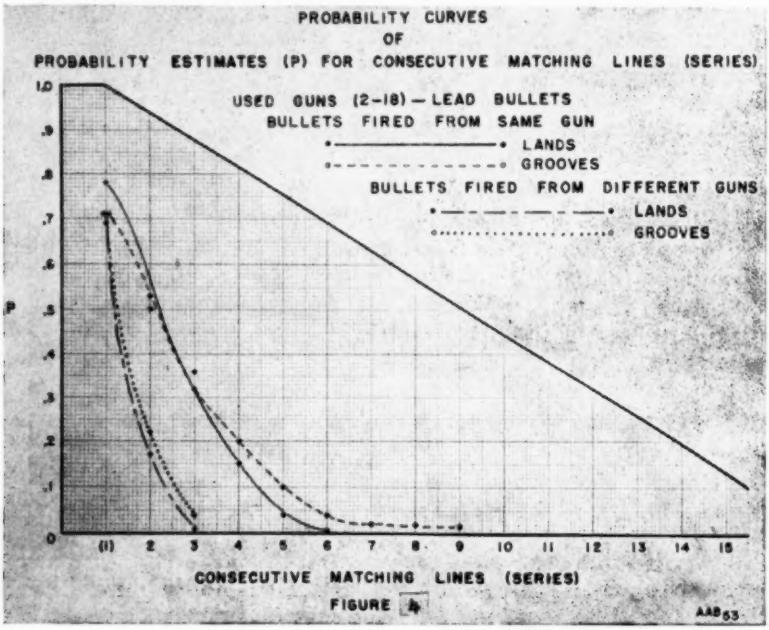

FIGURE 4

ing lines (series) for both bullets fired from the same gun and bullets fired from different guns. This is graphically demonstrated by Figures 4 to 8.

In comparing the data for same and different guns, it should be pointed out that in the case of data for same gun the interpretation of the criteria for consecutive matching lines was held strict, while in the case of data for different guns this interpretation was made liberal. It should also be noted that in comparing bullets from different guns, each consecutive land and groove mark of the question bullet from

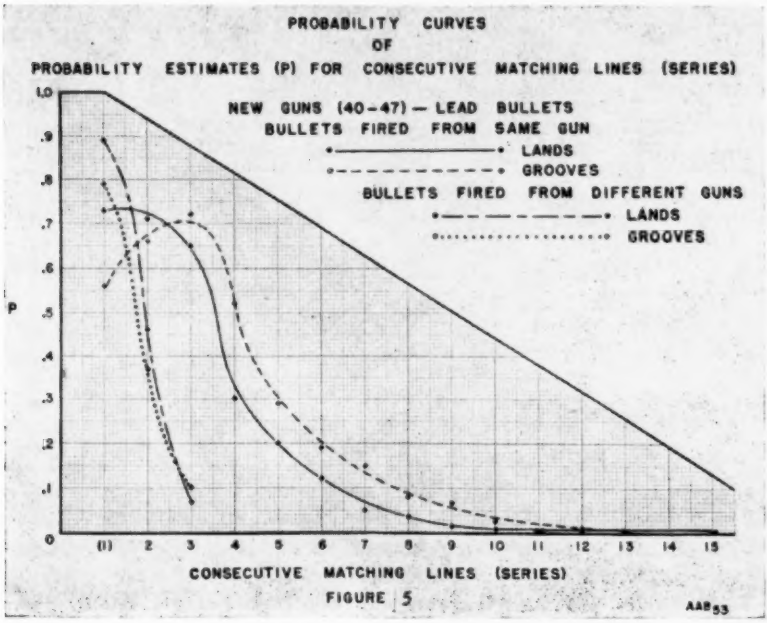

FIGURE 5

one gun was compared with the land or groove mark of a bullet from a different gun which appeared to be most similar in overall contour and degree of marking. Under these conditions the probability estimates for different guns should actually be less than those reported. This procedure was followed to counteract possible subjectivity on the part of the observer.

From a study of Figures 4 to 8, the following variables may be studied and compared: (1) Same versus different guns (Figures 4 to 6); (2) land versus groove marks (Figures 4 to 6); (3) used versus new guns (Figures 4 to 6); and (4) lead versus metal-cased bullets (Figures 5 and 6). To facilitate the comparison of all of the curves shown in Figures 4 to 6, the curves for land marks only are summarized in Figure 7 and the curves for groove marks only are summarized by Figure 8.

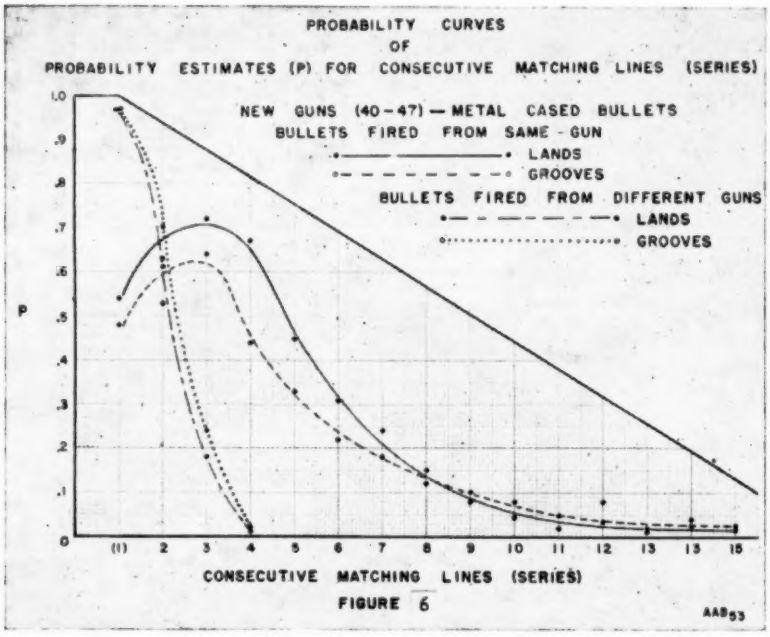

FIGURE 6

The most significant point of the data collected is the fact that 3 consecutive matching lines for lead bullets and 4 consecutive matching lines for metal-cased bullets appears to be the dividing line between data for same and different guns; and therefore, these critical series form the base line upon which the data for bullets from the same gun can be differentiated from the data for different guns. The fact that not more than 3 consecutive matching lines were observed in any

of the 360 different land and 360 groove marks for lead bullets from used guns 2-18 and new guns 40-47; and that not more than 4 consecutive matching lines were observed in any of the 180 different land and 180 groove marks for metal-cased bullets from guns 40-47 demonstrates that the criteria of consecutiveness can be very effective as well as being the only reliable criteria for establishing identity. The practical significance of this data should be readily apparent. On the basis of the data presented in this study, it appears that an

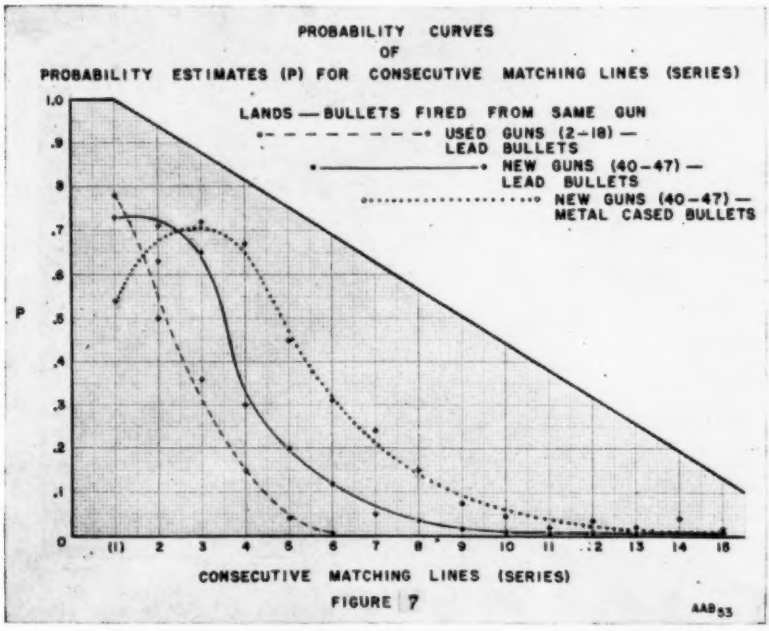

FIGURE 7

identity can be made with a high degree of confidence when only a relatively few matching lines are associated by consecutiveness.

The factual data reported in this study should contribute materially to answering the moot question of what constitutes the identity or non-identity of two fired bullets. Because of the great number and complexity of the variables involved in the reproduction of the markings on fired bullets much more

factual (statistical) data must be collected before any general verifiable laws can be formulated or before the data reported in this study can attain any real measure of practical significance. However, this lack of data should not deter the use of the data thus far reported in evaluating and substantiating current conclusions regarding identity.

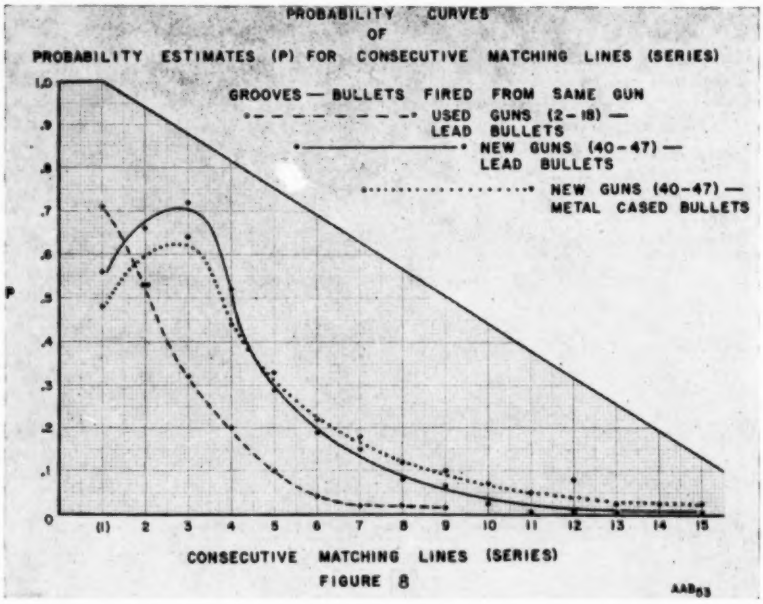

FIGURE 8

The data thus far collected can aid in the construction of a mathematical model which in turn can be used to predict the effect of various experimental variables before they are experimentally evaluated, thereby enabling a more efficient and effective study to be organized and conducted. In addition to the limited practical and statistical applications of the data reported, the most significant application will be to the organization of the future statistical studies necessary to enable the ultimate goal set by this study to be achieved.

## Summary

A short review of the statistical data collected from a study of the individual characteristics from two series of fired

bullets has been presented with the essential data summarized in table and graph form. The reader is referred to the orig-

EXPLANATION OF SYMBOLS AND CALCULATIONS

FOR FIGURES 4 - 8

PROBABILITY ESTIMATES (P)

$$P = \frac{x}{n}$$

x = total number of pairs of lands or grooves containing at least one or more series, e.g., (1), 2, 3....n (or at least two or more in tables 10 and 11).

n = total number of lands or grooves giving total x

VARIANCE ($s^2$)

$$s^2 = \frac{P(1-P)}{n}$$

P = probability estimate for each series, e.g., (1), 2, 3....n.

(or)

$$s = \sqrt{\frac{P(1-P)}{n}}$$

n = total number of pairs of lands or grooves giving P.

CONFIDENCE INTERVAL (C.I.)

95 % C.I. = (P + 1.96 s) to (P - 1.96 s)

ASSUMPTIONS:

(1) That n (the total number of lands or grooves giving the probability estimate P) is large.
(2) That there is a fixed number P (for a given: type, make, caliber of gun and ammunition, and experimental situation used) which is the true probability that one or more series, e.g., (1), 2, 3....n, will be observed on a random land or groove mark for bullets from the same, or bullets from different guns.
(3) That the observations x are independent.*
(4) That total observations X will have a binomial distribution:

$$p(X = x) = \begin{cases} \binom{n}{x} p^x (1-p)^{n-x} ; & x = 0, 1, 2, 3....n \\ 0 \quad \text{otherwise} \end{cases}$$

Other alternative:

$$y = \frac{x - np}{\sqrt{\frac{P(1-p)}{n}}}$$

* The test of independence given in Appendix III was applied to the data from guns 2-18 but the results failed to clearly indicate either independence or dependence due to the relatively small sample of guns used.

inal thesis (1) for a more complete presentation and discussion.

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1043 Blaney Avenue
San Jose, California

# The Effects of Oversedation During Pregnancy or During Delivery*

*Carl E. Wasmuth, M.D.,** Cleveland, Ohio*

The responsibilities of the anesthesiologist during delivery include rendering the mother analgesic or anesthetic and maintaining the maternal and fetal vital processes within physiologic bounds. Inasmuch as the obstetrician's attention may be wholly occupied with the mechanics of the delivery, the anesthesiologist may at times assume other responsibilities for the welfare of the mother and child. Such teamwork is most apparent during the difficult delivery. The anesthesiologist, in addition to administering the anesthetic agent, frequently resuscitates the sluggish infant, transfuses blood or gives emergency medication either to mother or to child. It is this co-operation and industry of the obstetrical team (12) that have resulted in decreased incidence of fetal and maternal morbidity and mortality.

The anesthesiologist's participation in the obstetrical teamwork has served to disclose many serious deficiencies in formerly accepted practices, and has led to many contributions to the field of obstetric anesthesia. In former years, induction of anesthesia was relegated to a technician or a nurse who would "pour ether." More noxious agents than ether have been administered over extended periods of time by obstetricians who often were inadequately trained in anes-

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** From the Department of Anesthesiology, The Cleveland Clinic Foundation, and The Frank E. Bunts Educational Institute, Cleveland, Ohio.

thesiology. Little attention was paid to the effects of the anesthetic agents on the mother. Little was understood of the deleterious effects of maternal anesthesia upon the fetus; fetal cerebral damage by anoxia must have been fairly common.

Since the advent of the medical anesthesiologist, great strides have been made in the field of obstetric anesthesiology. Trained specialists now administer the anesthetic agent with great skill and care. The number of accidents has lessened. New technics and agents have been introduced into the practice of obstetric anesthetization. No longer is it necessary for a mother with a full stomach to be anesthetized to the third stage of ether anesthesia for delivery and suffer the after-effects of vomiting. The profusely hemorrhaging mother is easily and more safely anesthetized with cyclopropane accompanied by more than sufficient concentrations of oxygen to protect the unborn fetus from anoxia.

However, the onset of labor seldom occurs with the precise planned stages of elective surgery. The mother might just have finished eating a sumptuous holiday meal. The voracious appetite of the pregnant woman is a well-known entity to every anesthesiologist. It is conceded that this overeating cannot be controlled by him, but appropriate conduction of anesthesia (13) can be employed and proper precautions can be taken to avoid the tragedy of the mother's vomiting and her aspiration of the vomitus. The development of caudal and spinal analgesia and new agents (16) has been a milestone in the progress of obstetrics. (14, 15) The maternal as well as the fetal life is no longer jeopardized by the effects of a general inhalation anesthesia, aspiration and anoxia (7).

The administration of narcotics and sedatives to the mother in various stages of labor has long been the subject of widespread controversy. Premedication with barbiturates and narcotics is administered only upon proper indication and in calculated doses. The use of barbitals was frequently abused in former years. Barbiturates possess no pain-relieving qualities. If given in doses sufficiently large to cause sleep during active labor, a relatively histotoxic anoxic effect is manifested in the fetus. Consequently, the infant will be sluggish when born and resuscitation will be necessary.

Frequently, the resuscitation of the newborn is accomplished by the anesthetist (6), who by training usually is the best-qualified person in the delivery room to assume the complicated problems of infant resuscitation. In the newborn, the period from the delivery until the initial, spontaneous respiration often depends upon the sedation and the type of anesthetic agent administered to the mother. Although the newborn still possesses an anaerobic system of respiration (8), resuscitation must be accomplished within a reasonable time after delivery to avoid the pathologic effects of cerebral anoxia (9). Resuscitation consists of suction of the nasopharynx followed by artificial respiration. The latter technic varies from the use of complicated mechanical respirators (11, 17) to mouth-to-mouth breathing. Should these simple measures prove futile, forced inflation of the lungs with oxygen by endotracheal intubation is necessary (18).

The ill effects of anoxia upon the fetus during labor and delivery cannot be underestimated. The possible causes of anoxia are innumerable. However, one of the most common reasons for its occurrence is the oversedation of the mother during labor. By the administration of narcotics, barbiturates and other anesthetic agents, the maternal physiologic processes of respiration and circulation may become compromised and result in pathologic effects on the fetus. The use of Nalline (N-allylnormorphine) hydrochloride and other narcotic antagonists, such as N-allylmorphinan tartrate, have been employed to combat the respiratory depression from narcotic drugs such as morphine, Demerol (meperidine) hydrochloride, Dolophine (methandone) hydrochloride, and Dromoran (racemorphan) hydrochloride. These antagonists are said to affect the respiratory center and to replace the narcotics by competitive action. The analgesic effects of the narcotics are maintained, but the respiratory depression is counteracted.

It is generally accepted that all anesthetic agents administered to the mother are transferred to the fetus (10). The placenta not only transfers oxygen and nutrients from the maternal blood stream to that of the fetus, but in reverse order, carbon dioxide and waste products are unloaded from the fetal circulation into the maternal circulation. However,

these functions of the placenta vary with the stage of the pregnancy and the molecular weight of the particular substance. It is readily understood that all substances cannot cross the "placental barrier." Particles with molecular weights less than 1,000 pass through by simple diffusion. However, substances having large molecular weights (6), such as plasma, do not pass across the intact placenta. The architectural units for fetal growth pass with ease. In fact, the placenta is said to have a selective power to transfer these particles (5). Amino acids, fatty acids, and glucose, the essential elements for fetal growth (4) having molecular weights of less than 1,000, easily cross the placenta. However, other substances in the maternal blood stream may be carried across the placenta. Although viruses do not usually pass the placental barrier, there are exceptions, when, as a result of pathologic lesions or immaturity of the placenta the virus succeeds in crossing to the fetus. The most important culprit is the virus of rubella, which may cross the immature placenta in the early stages of pregnancy. Since congenital defects result from this viral infection, some authorities believe that this infection is sufficient reason for advising a therapeutic abortion.

Most drugs have molecular weights of less than 1,000 and are considered as being able to be transferred easily across the placenta. The narcotics, the barbiturates, and the general anesthetic agents cross the placenta freely so that the maternal and the fetal blood are in equilibrium. What, then, is the effect of these agents, given at the time of delivery, upon the fetal physiologic processes? As a general statement, it may be said that the most important effect upon the fetus is anoxia. Potter (2) states that "because of the multiplicity of factors that may interfere with delivery of oxygen to the fetus before birth, or that may interfere with normal function of the lungs after birth, anoxia is responsible for a greater loss of life in the fetal and neonatal period than is any other known agent."

The fetus during contractions of the uterus is subjected to great pressures. The delicate balance of physiologic pressures in the fetal circulation is doubtless upset with each uterine contraction. The brain certainly is subjected to the

increased pressures and compressions when the fetus is in the birth canal. If the umbilical cord is shortened, knotted, or wrapped around the neck of the infant, circulation doubtless will be obstructed. Add to these possibilities of anoxia the administration of anesthetic agents and the depression of the vital processes of the newborn may become overwhelming. It is little wonder that babies delivered by elective cesarean section under spinal anesthesia experience such a benign and uneventful advent into this world.

Based upon etiopathogenesis, paranatal anoxia is divided into four classifications (3): (1) anoxic, (2) anemic, (3) stagnant, and (4) histotoxic.

*Anoxic anoxia* occurs as a result of breathing air that has a reduced oxygen content at normal atmospheric pressures. In the adult, it is brought about by obstruction of the airways sufficient to interfere with alveolar ventilation. Such a condition might occur during pregnancy at term when an inhalation anesthetic agent is administered without sufficient oxygen. The maternal oxygen level of the blood is lowered and the fetus similarly suffers a bout of anoxia. The onslaught might be too great to be overcome, although the fetus has the advantage of having anaerobic metabolism. A similar anoxia occurs when the oxygenated fetal blood flow is obstructed in the cord. On each contraction of the uterus some obstruction occurs because of the ambient pressures. When the cord is prolapsed or otherwise totally obstructed, anoxia may become pathologic in extent and cause serious aftereffects. Multiple bouts of temporary, and often insignificant, periods of anoxia might produce significant pathologic changes in the fetus.

*Anemic anoxia* is due to a reduction in the number of red blood cells and to the consequent decrease in the quantity of hemoglobin available to transport oxygen. This condition is most often found where the total blood volume is reduced by hemorrhage or in the anemias. Prior to birth, this condition is seen in hemolysis of fetal cells by maternal isoimmunization, i. e., an Rh negative mother being pregnant with an Rh positive fetus. Anemic anoxia might also occur when the umbilical cord is injured.

*Stagnant anoxia* results from any circulatory derangement in which the rate of blood flow is reduced. In obstetrics, such a condition can occur in heart failure of the mother, but this condition is rare.

*Histotoxic anoxia* occurs when the oxidative systems of the cells are inactivated or impaired and consequently the cells are unable to utilize the oxygen supplied. This type of anoxia is especially apt to occur at or during the delivery. The influence of the anesthetic and narcotic agents on the mother and infant are equal. The sequelae, which may not be manifested immediately, often leave their mark to be noted in later life. It is difficult, of course, to pinpoint the exact relationship of these effects. Suffice it to say that anoxia is considered the major cause of injury to the fetus regardless of the mode of its inception.

Paranatal anoxia is manifested principally upon the tissue of the central nervous system. Although no absolute proof was put forth, references to asphyxia of the newborn and its relation to later disabilities were published more than a century ago. The cells of the central nervous system are not uniformly affected by lack of oxygen. Primarily such an effect is manifested on the cells of the cerebral cortex and the corpus striatum. Such an effect is said to be due to the insufficiency of the circulation as well as to the decreased oxygen tension. Anoxia need not be caused by decreased oxygen tension of the blood. In fact, ischemia by cessation of the flow might cause enough anoxia of the brain to precipitate pathologic effects.

Such problems of anoxia occurred concurrently with the advent of the use of anesthetic agents for delivery. The administration of these agents was, in the early days of anesthesia, accompanied by varying degrees of anoxia. We all are familiar with the convulsions caused by ether, the cyanosis brought about by nitrous oxide anesthesia, and the respiratory paralysis consequent to spinal anesthesia. These are but a few simple and mild examples of a bout of anoxia. The brain cells were insulted, cerebral edema occurred (1) but the process was reversed before permanent damage resulted. But how many situations have occurred which have embarrassed

normal physiologic processes and, indeed, caused pathologic results in the fetus which have gone unobserved during the stress-filled moments of a difficult obstetric anesthesia?

In severe cases of cerebral anoxia, death occurs after a very short interval. In such cases, postmortem findings seldom reveal either microscopic or gross changes in the brain or other nervous tissue. Such is the sequence of events in anesthetic deaths.

Anoxia of lesser degree may produce a myriad of other physical effects. Among these are hyperemia, edema, and hemorrhage. Minute hemorrhages are to be found in the viscera, serous membranes and the brain. In the mild forms hyperemia of the various organs, especially of the brain, lungs, and kidneys, produces severe edema. This can only aggravate the initial physiologic trespass. Anoxemia implies a generalized deficiency in the oxygen supply to the nervous tissues during intra-uterine life and delivery. Generalized changes or atrophy of the cerebral hemispheres may be expected, and usually are found, in mentally defective children. Occasionally, these changes are associated with convulsive episodes and various degrees of motor disturbance. Microscopic examination reveals a reduced number of pyramidal elements. The loss of cells is more or less proportional to the degree of atrophy present.

The acute phase of anoxemia initiates an ischemic phase. The anoxemia itself causes a reduction of the blood flow by partial physical occlusion, by transitory functional constriction of the nutrient arteries or by edema. This ischemia then is just a different kind of anoxia. It is a decrease in circulating blood to a part in contradistinction to a lessening of the oxygen to the tissues. Courville points out that this phenomenon explains the local effects of focal degeneration and sclerosis of the cortex and basal ganglia. This occurs only if the vasoconstriction of the arterial supply or the edema is sufficiently severe and prolonged as to cause regressive changes in localized areas. When the constriction is less severe but long continued, there is reason to believe that the central white matter becomes affected and that cystic degeneration or progressive demyelinization results.

**Summary**

It is evident that the role of sedation of the mother and its effect on the fetus are significant. However, it is difficult to separate this from the other innumerable causes of anoxia during labor. The various degrees of anoxia produce various and often unpredictable effects on the fetus. Inasmuch as the newborn still possess an anaerobic system of respiration, the effects of a prolonged period of anoxia might be mitigated. The advances made in obstetric anesthesia in the last decade have done much to prevent these deleterious effects of anesthetic procedures, but the problem of cerebral anoxia is still one of major proportions. The slight but repeated bouts of subclinical anoxia must still extract a significant toll in cerebral degenerative conditions.

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Cleveland Clinic Foundation
Cleveland, Ohio

# Some Medicolegal Observations on Infanticide*

*Lester Adelson, M.D.,** Cleveland, Ohio*

## Introduction

Infanticide has been practiced by many primitive and even so-called civilized societies since time immemorial. Not only was it not considered a crime, but in some instances it was practically mandatory to dispose of any child whose birth portended disaster for the family or social group. Local custom, tradition and taboo determined which child was doomed at birth. In darkly-pigmented racial groups, the birth of an albino was often followed by its prompt disposal. In societies with a constantly critical food supply, the arrival of twins frequently led to the destruction of at least one child. If an augury about a child foretold disaster, it was deemed prudent to kill or expose the child before matters went too far. This is the foundation of the Oedipus legend. Poverty and ignorance were formerly the major bases for infanticide. Today the social stigma attached to pregnancy out of wedlock is the most important etiologic factor. However, the crime is not limited to the unmarried.

Social and legal attitudes toward infanticide have changed radically with the passage of time. Modern society condemns the practice and provides severe punishment for the offender if and when the crime is proved and the culprit is apprehended.

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** From the Laboratory of the Cuyahoga County Coroner's Office, and the Dept. of Pathology of Western Reserve University School of Medicine, Cleveland, Ohio.

This brings us to the root of the difficulty—proving that a crime has been committed and apprehending the suspect. In no other type of homicide is it as difficult to establish the *corpus delicti* as it is in infanticide. Although the crime is ancient, not uncommon, and has been studied intensively for many years, it still plagues the forensic pathologist and frustrates law enforcement authorities.

It is manifestly impossible to gather reliable statistics on the incidence of infanticide because so many cases are undiscovered, never proved or rarely solved. Even in cases with gross trauma which points unmistakably to intentional violence, the number of arrests is extremely low, and the number of convictions is even lower. Only a small fraction of all infanticides is diagnosed and solved to the satisfaction of those responsible for investigating or adjudicating the crime. For this there are several cogent reasons.

In Cleveland and Cuyahoga County, as in any metropolitan community, the finding of dead newly-born children in sewers, alleys, incinerators, trash dumps, streams, lakes, parcel lockers, women's public lavatories and the like is a frequent occurrence. Rarely is there adequate evidence to point to or even give a lead to those responsible. In Cuyahoga County there have been but 5 convictions for infanticide during the past 22 years (1). Within a period of a few days during the past year, 2 cases of infanticide came to our attention, and in both cases arrests were made and convictions obtained. These two cases are the only such instances in my experience during the past 7½ years at the Cuyahoga County Coroner's Office. These two murdered infants furnished the stimulus for some thought to help crystallize the problem and put it in its proper perspective.

Case 1 (Cuyahoga County Coroner's Office #84992):

The body of a burned newborn colored male was found near a trash heap which had recently been on fire. Pieces of flesh, bone, burned cloth and charred rubbish were scattered about the area. The police questioned the inhabitants of an adjoining house, amongst whom was a middle-aged married woman, the mother of four children. After some interrogation she admitted that she had suddenly given birth to the child at about 2 A. M. on the preceding night. Her husband was at work at the time, and her four children were asleep. She wrapped the infant in a bedspread, went to the kitchen where she obtained matches and newspapers, put the child on the rubbish

pile in the back yard and set it aflame. She watched the fire for 10 or 15 minutes and then returned to the house. She stated that the child appeared dead, and that she was merely trying to save the expense of a funeral. She also remarked that her last menstrual period had occurred in July 1956 (the child had been born on March 29, 1957), and that she had tried unsuccessfully to abort herself with pills. She was taken immediately to Cleveland City Hospital where examination indicated recent parturition without post partum complications.

Autopsy revealed a newborn male weighing 1625 grams (3.58 lbs.) and measuring 45.7 cm. (18 in.) from crown to heel with moderate heat contractures of the legs. The right arm was submitted separately. Extensive soft and bony tissue damage were present, apparently caused by dogs. Partial or complete destruction of the head, trunk, left arm and both legs was noted. The scalp was destroyed, and the bones of the cranium were loose, disintegrating as they were examined and exposing the interior of the cranial cavity. Two and five-eighths inches of charred umbilical cord were *in situ*. The right chest wall, right lung and part of the heart had been eaten.

The blood remaining in the cardiac chambers was solid and pink, and the tissues generally were pink. Several fluid-containing vesicles, confirmed microscopically, were noted on the dorsum of the tongue. The pulmonary alveoli were partially expanded, and many were filled with blood. Chemical analysis of the clotted blood was positive for carboxyhemoglobin.

Fig. 1, Case 1—Fluid-containing vesicle on surface of tongue.

The anatomic findings justified a diagnosis of live birth with death due to incineration. The mother was indicted for

murder in the first degree because of the evidence of premeditation as shown by the deliberate procurement of matches and paper used to start the fire. She was ably defended by competent counsel who stressed to the jury the low mental calibre of the defendant and the fact that she might well be unable to determine whether or not the child was actually alive before she consigned it to the flames. The defense was premised on the proposition that the macabre situation was nothing but a crude attempt to conceal the birth of the child. Information that her husband might not have been the father of the child was introduced by the prosecution. The jury returned a verdict of guilty of manslaughter in the first degree.

Case 2 (Cuyahoga County Coroner's Office #84974):

An 18 year old unmarried white female was found bleeding vaginally in the bathroom by her mother. The girl was conveyed to a hospital over her protests where a placenta was extracted. When questioned concerning the whereabouts of the child, she said that it was in a clothes hamper in the bathroom. Her father rushed home and found the child wrapped in newspapers in the hamper. He returned immediately to the hospital with the infant where it was pronounced dead on arrival.

Blood-soaked towels and newspapers and a bloody Boy Scout knife were found in the bathroom by the police. The parents denied all knowledge of their daughter's pregnancy, although the mother admitted that she knew that her daughter, who lived at home, had had no menstrual periods since July of the preceding year. (The birth occurred on March 27, 1957.) It might be added that the girl was rather small and slender. However, the mother was "certain" that her daughter could not be pregnant because "she was not the kind of a girl who would get into that kind of trouble." So much for the sociologic aspects!

At autopsy the child was a full-term newborn white female weighing 2900 grams (6.38 lbs.) and measuring 51 cm. (20 in.) from crown to heel. The umbilical cord had been cut off close to the abdominal wall. Thirty-three superficial and deep stab wounds were present over the neck, chest and abdomen, anteriorly and posteriorly. Many of the deeper wounds communicated with corresponding injuries in the cervical, thoracic and abdominal viscera. A loop of gut had herniated through a stab wound in the left upper quadrant of the abdomen. The lungs were well-expanded, and there was sufficient blood in the body cavities and extravasated into the tissues to indicate active circulation at the time of stabbing.

The girl was indicted for murder in the second degree and pled guilty to manslaughter.

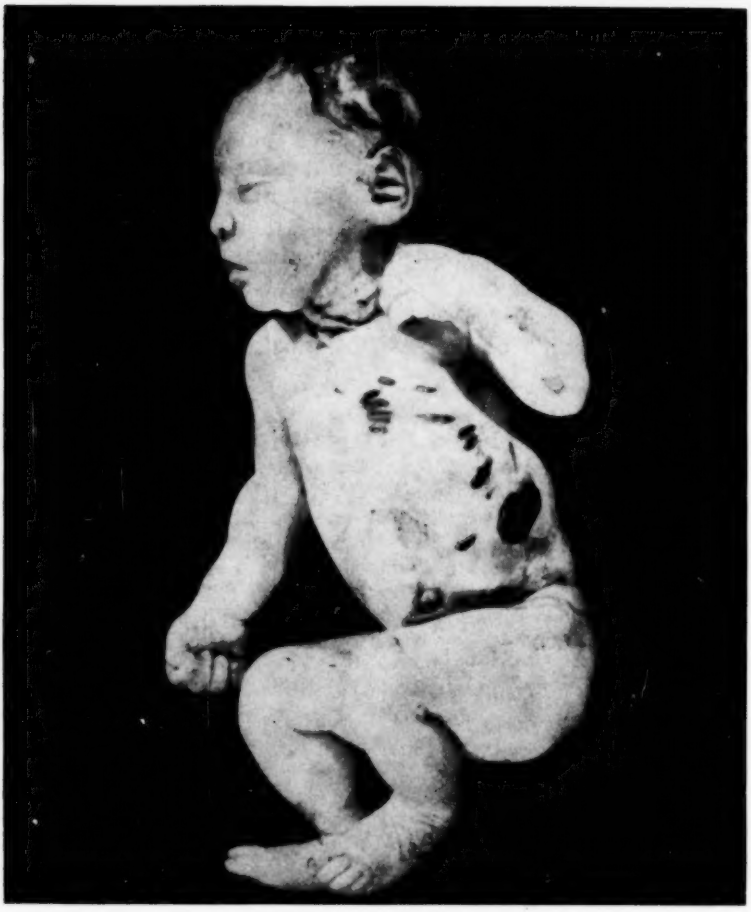

Fig. 2, Case 2—Anterior view of infant showing multiple stab and incised wounds.

## Discussion

From the medicolegal point of view, infanticide investigation presents many problems similar to those encountered in other homicide investigation, with the difference that the solutions to these problems are much more elusive or unattainable in the newly born. Moreover, infanticide raises some questions which are unique.

In order to constitute a homicide, the human being whose life has been destroyed must be living. To constitute infanticide, the child must have been totally expelled from the mother's body, must have lived an independent existence after

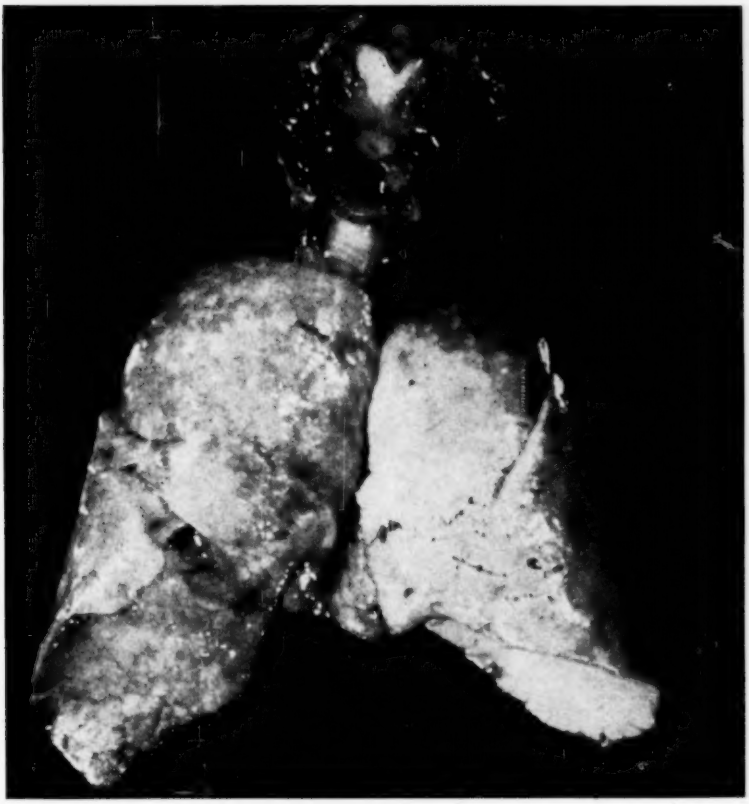

Fig. 3, Case 2—Gross photograph of lungs.

such expulsion, and its death must have been caused by violence inflicted on it by some other person after the commencement of its independent existence (2). The wilful killing of an unborn quick child by an injury to the mother, which would be murder if it resulted in the death of the

mother, is held to be manslaughter or some other degree of homicide in many states (3). This is a completely different problem.

Complete expulsion means that the child must be entirely extruded from the birth canal. Killing a child, one of whose legs is undelivered, is not infanticide. The cord need not be

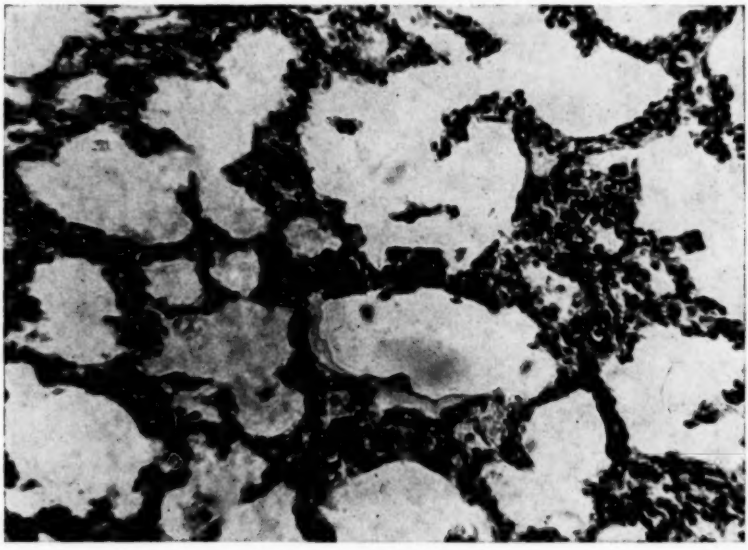

Fig. 4, Case 2—Microphotograph of lung showing complete expansion.

cut nor the placenta delivered to comply with this provision of the law. The crux of the situation is the stipulation that the child must be "alive and have an independent existence." The law distinguishes fetal life from independent life which cannot exist until the establishment of an independent circulation or, more specifically, independent respiration. In this respect the law holds with Barcroft (4) who said, "Breathing is living; the onset of respiration is the beginning of life." The burden to establish this fact rests on the state. In the absence of positive proof that independent respiration was present, there is no crime.

Unless the child has reached a stage of development consistent with the possibility of independent existence, a charge of infanticide or child murder should not be made. Although pediatricians and hospitals accomplish seeming miracles in keeping alive extremely immature infants, courts have held

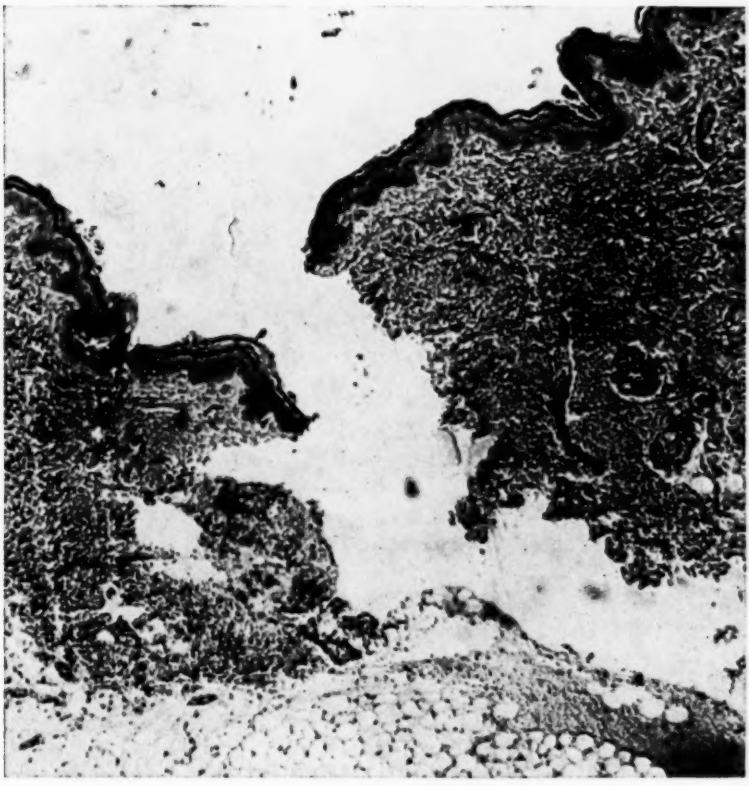

Fig. 5, Case 2—Stab wound of skin.

that an infant of less than 28 weeks gestation cannot maintain a separate existence. A child of less than 7 months gestational age is presumed to be incapable of life solely because of its immaturity (5).

It is a widely acknowledged fact that even after complete autopsy with careful gross and microscopic studies, no satis-

Fig. 6, Case 2—Stab wound of trachea with acute hemorrhage, indicative of active circulation.

factory conclusion can be reached as to the causes of many stillbirths and neo-natal deaths which occur despite the availability of competent medical attention and observation.

The pathologist frequently faces an insurmountable problem when he examines the remains of a child whose birth was not witnessed by anyone willing or able to tell what has happened. Texts of legal medicine describe a variety of details useful in differentiating live births from stillbirths. But, for practically every positive finding described as diagnostic of live birth, there is usually a caveat that this finding *per se* is not always pathognomonic. The hydrostatic test of the lungs, the aspiration of meconium, the presence of gas in the stomach, etc. must be cautiously interpreted in the light of all anatomic findings and whatever clinical data are available. Even the presence of partially expanded pulmonary alveoli is no guarantee of post-partum respiration. Vagitus uterinus and vagitus vaginalis prove that respiration can occur long before birth is complete. There can be no disagreement with Simpson (6) when he states that the microscopic appearance of the lungs, formerly accepted as diagnostic of extra-uterine respiration, offers great difficulties to the "honest pathologist." Many cases of stillbirth, delivered at or near term, show definite evidence of space formation in the air sacs (7). When all the data are assembled, the unbiased observer will frequently be forced to make the non-committal diagnosis "Term (or premature) birth, ante-natal or neo-natal death undetermined." Unless the pathologist has unequivocal evidence of extra-uterine respiration or some other findings indicative of post-partum survival (food in the stomach, vital reaction in the umbilical cord) he is morally and legally bound not to make a diagnosis of infanticide. Convictions for infanticide have been set aside when it has been doubtful whether or not the child was born alive. The courts have pushed this proposition to the point where the state has been forced to prove that the baby was born alive beyond *any possible doubt* rather than beyond reasonable doubt. Any question should be resolved in favor of the accused. On this basis alone, many cases of infanticide never appear in court.

This is not to gainsay the fact that many deaths certified as antepartum or intrapartum deaths or as deaths due to natural causes in the immediate post-partum period are probably unnatural deaths due to deliberate acts of omission or commission. Occluding the air passages with the hand or by

holding the infant face down in the bedding or submerging it in water before breathing has started or shortly after its inception produces changes indistinguishable from those found in stillbirth or in natural neonatal asphyxia. These cases are recorded as natural deaths because there is no good evidence to support a contrary opinion. Suspicion is not proof. The well-known higher incidence of "stillbirths" in illegitimacy undoubtedly includes a goodly number of criminal infant deaths, but the facts essential for proof are beyond reach.

Although several European countries have special acts to cover infanticide (viz., England, Germany, Austria) in the United States infanticide is usually considered a form of homicide and prosecuted as such. Inasmuch as it is extremely difficult to prove the crime, many states have in their codes the more easily prosecuted offense of concealment of birth. In Arkansas the law states that if any woman endeavors privately, either by herself or the procurement of others, to conceal the death of any issue of her body, that it may not come to light, *although it cannot be proved that it was murdered,* every such mother shall suffer the same punishment as for manslaughter. (Ark. Statutes, P. 2991.) Colorado inflicts punishment for concealing the death of any issue which "if born alive, would be a bastard." (Colo. P. 51, C. L. 6682.) Florida has a law (P. 7151) which provides that any woman indicted for the murder of her infant bastard may also be charged in the indictment with the offense of concealing the death of a bastard child (P. 7150). If upon trial she is acquitted of murder, she may be found guilty of concealment. Missouri does not differentiate between legitimate and illegitimate issue and punishes concealment of birth by a term of not more than 7 years in the penitentiary. (Mo. Statutes Annotated, P. 3990.) New Hampshire and Vermont also provide severe punishment for concealment of the birth of any child which would have been a bastard had it lived (3). With these types of laws, convictions can be obtained where the state would fail with prosecution for homicide, even in those cases where there is strong moral conviction that murder has been committed.

## Identification

Rarely is a suspect apprehended in an infanticide investigation. The two cases previously detailed are the exception. The major stumbling block to the successful solution of the crime, once wilful violence has been demonstrated, is the inability to establish the identity of the victim. In infanticide, as in any unwitnessed homicide, police investigation properly begins with the establishment of the identity of the body. This is extraordinarily difficult and usually impossible with a newborn. The newly born all share a common anonymity. Even when the body is well preserved and the manner of death is obvious, it is most unusual that one is able to identify the child and its origins. When putrefaction or postmortem destruction by fire or animals is well advanced, it may be extremely difficult to establish such a fundamental factor as the racial background of the child. The obscure and hidden places where such children are deposited or the fact that their location may be frequented by large numbers of women militate to make the search for identity well nigh impossible. Almost without exception these cases are filed under the appellation of unknown white male infant, unknown colored female infant and the like.

## Summary

A few salient medical and legal problems arising in connection with infanticide have been presented and briefly discussed.

Two unusual cases of infanticide where convictions were obtained are communicated.

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*Acknowledgment.*

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2121 Adelbert Road
Cleveland, Ohio

# Establishment of the Time of Death—A Critical Assessment*

*Francis E. Camps, M.D.,** London, England*

This problem has exercised the minds of those practising forensic medicine in England just as much as it has in other parts of the world. It is surprising, therefore, that when the history of the subject is studied, it seems that until recently little original thought has been directed to it. Most textbooks have been content with old dogma or copying observations and statements from edition to edition. These depend basically upon three common observations—

1. The fixation of hypostasis.
2. The state of rigor mortis.
3. The temperature changes from heat loss.

To these may be added collateral observations such as the condition of the stomach contents (i. e., amount and state of digestion), the contents of the small and large bowel, and in longer periods since death, putrefactive changes, maturity of larvae, state of vegetation beneath the body and mould formation.

I do not propose to give here a recapitulation in detail of those matters upon which opinions have been based in my country but rather to challenge your minds as to what we really want to know and how we may possibly set out to achieve our end. With this in mind it is essential that it

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** Reader in Forensic Medicine (University of London).

should be realized that in every investigation there is evidence which is investigational but not necessarily evidential. One other matter that may lead also to confusion is comparison between time of inquiry and time of death.

First, I feel that we should get the whole matter in its true perspective. Lyle and Cleveland (11) state "there have been numerous instances in which the knowledge of the *exact* time of death has been of great importance." One is tempted to ask the particulars of such cases or even ask whether it is the time of assault or death which matters. Of course, nobody is denying that such information if it could be obtained could occasionally be of great value especially in civil actions but only if placed on a scientific basis. Unfortunately, our speciality has not yet achieved the right to claim such distinction except perhaps in chemistry. Thus an ability to assess the time accurately to within an hour in less than nine times out of ten would be valueless. Further, it must have a true scientific backing both on an experimental and statistical basis for otherwise the evidence might possibly be dangerous to the interests of justice. To offer a comparison, a dogmatic postulate in a case of poisoning of the time of administration, should it be destroyed evidentially, must be followed automatically by an acquittal of the accused even if guilty. So, too, a case based upon an exact time of death will have the same result if contrary evidence is produced.

I would suggest that our aim should be to obtain a figure with as small a margin of error as possible; in fact, I would say that it is better to prove without contradiction that death *could* have occurred at a time when a certain person was there, rather than it *did* occur at some exact moment.

Adopting such a wide conception how can an opinion be founded upon a scientific basis? It would seem that in order to achieve any degree of accuracy under conditions which cry out statistically for wide variability, the only approach must be by a number of observations, which, although they may be variable, will include amongst them some common factors. With this in mind let us turn to the traditional five observations—

1. The Fixation of Hypostasis—

This is certainly a lot more variable than is suggested in textbooks, viz. 6–8 hours. I have seen fixation in one hour and non-fixation in twelve hours. True fixation must be due to post-mortem coagulation of the blood but how can allowance be made for fibrinolysis? Clearly it must be accepted that the cause and circumstances of death will cause great variation.

To quote Casper (5) "It is not easy to understand how the existance of coagulated blood in and upon a wound in a dead body can lead to any certainty to the conclusion that such an injury must have been inflicted during life *because blood cannot coagulate after death!*' This is but one of the many erroneous opinions which have obtained currency in forensic medicine by its being left in the hands of pure theorists; so, for example, Henke (8) quotes this "Coagulation of the effused blood in ecchymosis," as a sign that the violence which produced it must have been inflicted during "life"; and when we consider the great estimation in which Henke was so long held as an authority in this department, we cannot wonder that even medical boards of enquiry, as I well know, should still maintain the opinion that coagulations of the blood found in the body must have formed during life!

Engel (6) most correctly says "I do not believe that there is any disease or kind of death in which the blood does not coagulate in the dead body, it may happen in any case that the blood is not coagulated—but there are always other cases of the same disease or kind of death in which the blood is coagulated."

Bock (1) indeed fixes a time (about 4 hours) after death when he supposes the coagulation of the blood to begin. Whence do I quote this?—"Recent Advances," Casper (5), April 1860.

Let me add a quotation from a famous trial "Blood might remain fluid up to 12 hours—if longer asphyxia would be the cause of death" or another witness in the same trial "He was satisfied that the bodies must have been drained of blood within a few hours." (1937, The Ruxton Case.) Nevertheless, it does throw a light on the critical outlook of modern thought,

for it has been stated "in view of the important work in the same field by Schourup which effects considerable advance." This considerable advance turns out to be a method which is—

1. Only applicable to adults over the age of 15 years.
2. Requires no contamination of cerebrospinal fluid with erythrocytes.
3. Excludes all cases in which injury has allowed escapes of cerebrospinal fluid.
4. Postulates that death must have occurred within 15 hours prior to withdrawal of cerebrospinal fluid.

At the same time it gives only a 3 hour margin of error up to 15 hours! It is also significant that, in fact, it was worked out in cases who died in the hospital.

2. The State of Rigor Mortis—

This is classically stated to be established fully at about 10–12 hours after death but it will also be accepted that in some cases the period may be shorter! — or longer! Factors alleged to exert influence include the muscular state of the person—the physical condition—the cause of death and the temperature. Not only may the onset time be variable but the length of time once established, as well as the time when it may commence to pass off. Further, it has been suggested by Shapiro (16) that the bulk of the muscle may be of significance and that the changes are going on at the same time in different places and not in a nice orderly manner as might be envisaged from some descriptions. A series of possibilities, fascinating maybe, but not scientific except possibly when studied by meat packers.

3. The Temperature Changes from Heat Loss—

Apart from the large number of variables such as physical development, clothing, temperature of the surrounding air, cause of death, there is (as well pointed out by Lyle and Cleveland (11)) variation according to the site at which the temperature is taken, viz., mouth, skin, rectum, liver or muscle. Camps and Purchase (4) have shown that using rates of cooling quoted by different authors, the estimated interval

when the temperature is 85° F. can vary from 2½–9 hours. Shapiro (16) has suggested that the liver temperature should give the most accurate figure being a large mass whilst Cleveland and Lyle (11) state that liver and rectum show closely related rates although the brain is possibly the most accurate.

In spite of these observations, the fact remains that although attractive, they do not achieve scientific accuracy. Indeed, how can they when so many variables exist? Attempts to avoid the margin of error have been made by correlating the body heat loss with the surrounding air temperature but is this always constant?—a door may be opened, a fire lit (or put out), a climatic variation in external temperature occurs either up or down. Is it scientifically possible to allow for all these in retrospect?

4. The Stomach Contents—

The state of digestion in relationship to the last meal is not constant for both digestive processes and pyloric relaxation are variable which cannot possibly be assessed physiologically, whilst the psychological element involved is quite unpredictable. The nature of the last meal is, however, valuable information.

5. The Cerebrospinal Fluid—

Mason (13) and Schourup (14, 15) claimed that examination of the cerebrospinal fluid will establish a time of death. The value of this has already been mentioned.

From this evidence, there is a fear in my mind that any claim to state an exact time of death fraught as it is with possibility of error, might lead to the conviction of an innocent person. I would, therefore, reiterate the view to say in evidence that *it would be possible* for death to have occurred (or impossible) at a specified time is the limit of safety at the present time.

Nevertheless, the problem offers a real challenge to the speciality of forensic medicine which should be capable of partial solution in the light of modern research. Before discussing the matter further, I should like to quote some cases without comment which emphasize our fallibility.

1. A man was found dead hanging from the banisters of an army building. It was clear from the presence of hypostasis above and below the ligature mark that he was dead before he was suspended. Evidence which was completely irrefutable showed that he was suspended within one hour of death. Hence the hypostasis was fixed in one hour.
2. The torso of a man was recovered from a river, the head and legs had been cut off. Post-mortem changes were present but the tissues gave an appearance of pickled pork! The skin was loose and also the nails. From this the opinion was given that he had been in the water about 21 days. This later proved correct, but it had already been explained to the police that this was still an inspired guess.
3. Three women were found dead in the closet of a kitchen. They showed varying but indefinite stages of decomposition. Vaginal swabs in all cases showed well staining spermatozoa. The time of death was later established as 14–21 days, 8 weeks and 9 weeks. On current views at the time, spermatozoa should have lost their morphological characteristics much earlier. What factors influence disintegration of spermatozoa and their staining properties.

To sum up—from the examples I have quoted you will doubtless agree that estimating the time of death is not an exact science. The best we can achieve is a reasoned guess taking into account all the known factors and our aim should be to limit the margin of error inherent in assessing the effect of these factors such as the substitution of the percentage cooling curve evolved by Fiddes (9) (which takes account of atmospheric temperature) for the present assumption of a constant rate of cooling of 2° per hour.

Each known factor for which an approximate correction can be made—configuration of body, clothing, surroundings, position and cause of death—carries with it a margin of error, in some cases a very large one, and the maximum possible error (as errors follow the laws of algebra) is ± the sum total of the individual errors. On this basis for a recent death we might even arrive at the farcical situation of the possibility of the person still being alive on the basis of time limits. In practice the situation is not as bad as here presented because our time limits are affected, and may be reduced to the times when the person was last seen alive and found dead. Moreover, in practice also it is highly unlikely that all the errors will be in the same direction and the probable error (the limits within which half the estimation will lie) will be very much less.

Having tossed a grain of comfort your way I must now remove it by saying that there may and probably will be some unknown factors for which allowance cannot easily be made such as fires, draughts, curtains and local variation in atmospheric temperature. Some may be eliminated—of there being no sun, the drawing or not of the curtains does not matter; some can be allowed for—if we know how many people have been in and out of the room and how often, and how long, the door remained open or shut; but there will always remain the possibility that fires may have been lit or let out by the "late lamented" and/or his associates at or near the time of death. A very hypothetical case found, according to the rate of cooling, 6 hours after death is a problem.

All this boils down to the fact that, as I said earlier, we should seek to provide reasons why the death could and probably did occur within certain times that purport to state when it did, in fact, occur.

| | Estimate Hrs. | | Error Hrs. |
|---|---|---|---|
| Time interval since death (on basis of cooling) | 6 | ± | 1 |
| Adjustment for | | | |
| (a) Configuration of body (fat) | 1 | ± | ¼ |
| (b) Clothing (thin) | —2 | ± | ½ |
| (c) Position | | | |
| (i) hot room | 2 | ± | ½ |
| (ii) draughty | —1 | ± | ¼ |
| (d) Cause of death (strangled) | 1 | ± | ¼ |
| Net time interval allowing for factors | 7 | ± | 2¾ |

So far this paper may have appeared to be destructive. Such was its intention for I speak with feeling on the importance of a true assessment of scientific evidence and avoidance at all costs of a miscarriage of justice. So, too, do I feel that one must avoid being carried away by one's own enthusiasm so as to lose a true perspective. In other words, I feel that at present the time of death resembles somewhat the value attributed in some people's minds to the lie detector. An ex-

cellent investigational instrument but not of such great value as an evidential weapon. Although I may have appeared unduly critical I should like to express my admiration for the work of Lyle and Cleveland (11) and I hope that very soon I shall hear of further encouraging results from these painstaking and accurate workers. At the same time, I should like to draw your attention to the work of Fiddes (9) and others carried out in Professor Douglas Kerr's department in Edinburgh. This conception is based on sound mathematics and involves what is described as a virtual temperature difference and virtual cooling time. The percentage cooling rate curve can be used if two or more temperature readings are taken over a space of several hours and the prevailing atmospheric temperature is noted. Reference to the curve will permit the estimation of the virtual cooling time and thence the time since death to within an hour or so. The temperatures were recorded in the rectum and the rectal temperature assumed to be 99.0° F. at time of death. This appears to offer advantages over the method described by de Saram who has also endeavoured to express the influence of the modifying factors by means of a mathematical formula. He should be credited with the observations that in addition to radiation, conduction and convection, evaporation also plays a part. Fiddes (9) comments that the liver may prove to be more reliable.

Finally, in conclusion after exploring the possibilities in my department of glycogen change after death, I have pleasure in submitting a short preliminary report of unpublished work which has been carried out by Dr. Samuel Kolmen of the University of Texas (Galveston), research assistant in my department, and Dr. C. W. Parr of the Department of Biochemistry (The London Hospital Medical College) who state "The use of enzymes for the estimation of the time of death is a possibility. It would appear that an enzyme remains fully active for a time after death and then decays down to zero at a rate which is characteristic for each enzyme. This overall period varies widely from approaching zero for labile enzymes up to a number of hours after death for stable enzymes. One might thus make some estimate of the time elapsing since death by measuring the activities of a small group of selected enzymes, and then consulting experimen-

tally derived graphs which relate enzymic activity with time after death." Preliminary studies along these lines have been undertaken by us using glucose hexosesomerase, glucose 6-phosphatase and phenyl-phosphatase as the enzymes under study.

The biological variation in the level of an enzyme in any healthy viable tissue is likely to be of the order of plus or minus 15 per cent, and thus a decrease in enzymic activity of at least 15 percent is necessary before it could be considered to be significant. Thus for a stable enzyme which might take several hours at 37° F., it is theoretically possible to assess the time of death to a degree of accuracy of about 30 minutes, during the first few hours after death, by means of enzymic assays.

The most likely approach seems to lie in considering the activities of a group of enzymes of varying degrees of stability. Expressing the activity of a labile enzyme as a ratio of the activity of a stable enzyme may to some extent compensate for the biological variation, provided the assumption, that a healthy tissue low in one enzyme will tend to be low in all enzymes, be valid. For instance, the ratio of the labile glucose 6-phosphatase to the stable phenyl-phosphatase at pH 6.5. decreases in a predictable manner within the time of aging at 37° F. of liver homogenates.

Of course, the results of enzymic assays must be considered in relation to the environmental conditions and temperature of the liver or other tissue selected, and corrected for accordingly. Other problems to this enzymic approach include—

1. Selection of the appropriate enzymes.
2. Development of techniques which will produce reliable and consistent tissue homogenates for enzymic assay.

On the other hand, as understanding of enzymology grows, so is this approach likely to become more and more useful. It is hoped that other investigators will join in exploring this enzymic approach to this old, yet vital, problem of estimation of the time since death.

From a practical point of view, it is visualized that the relevant material will be collected by the use of a trocar attached to a thermoelectro coupler. Thereby liver puncture would

be practical without disturbing the body and the temperature at the time of removal be available. Is it perhaps over optimistic to say that thereby one day we may have the best of both worlds, Enzyme assay and Temperature loss!

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37 Welbeck Street, W.I.
London, England

# A Short History of Microphotography (High-Reduction Photography) *

*A. Cuelenaere,** Ghent, Belgium*

It seems to be in the nature of the human mind to try to attain the extraordinary. People have attempted, most probably ever since they could write, to reduce their writing to as small a scale as possible. Cicero (1) is reputed to have stated that the whole Iliad had been written on a fragment of parchment which could be enclosed in a nutshell, while Claudius Aelianus mentions the case of a man who wrote a distich on a grain (2).

This art was not lost through the centuries for, in 1890, the Frenchman Cossoval wrote 63,700 words on a piece of paper measuring 116 × 100 mm. and, half a century later, the ability to write 60,000 words on a postcard won a German, Schmiz, the doubtful privilege of enlistment in the Nazi Intelligence.

Mechanical engraving devices have also been used for this purpose in the last century. An apparatus called the "micropantograph" was invented by a London banker, W. Peters, in 1852, and another copy was built later, for Alfred McEwen, according to the original design (3). Another similar apparatus (or was it the same?) was described by Dr. Lardner in 1855 (4) and an analogous device was developed by the French Colonel C. Dévé in 1925 (5).

It should, therefore, cause little astonishment that, with the advent of photography, man sought to apply the new

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** Laboratory of Criminalistics, Ghent University, Belgium.

invention to the production of highly reduced images, for which the word microphotography was originally coined. This term has unfortunately been used (this more so in continental Europe than in the English speaking countries) to designate the use of photography for the recording of images as seen through a microscope, instead of the word photomicrography which should be used in this instance.

The first really successful microphotographs were made by the Englishman Dancer as far back as 1852. The Frenchman Dagron used the method during the war of 1870 for the transmission of messages by pigeon-post from unoccupied France to the beleaguered city of Paris (6). The process was perfected by the German Goldberg in 1925 who obtained reductions of about 2500 diameters (7).

In the meantime microphotography had been used a great deal in various countries for the commercial production of curios and souvenirs. Microphotographs of monuments, for example, e. g., being imbedded in objects such as brooches, pencils, pocketknives, the necessary magnification being obtained by means of a Stanhope lens.

Nevertheless, when the Germans used a somewhat refined process in the war of 1940–45 for the purpose of espionage, it came as a surprise to the allies, as Mr. J. E. Hoover frankly admitted in an article (8) to which American microphotographers reacted rather sharply (9).

We present herewith "photomicrographs" of three "microphotographs" made by the German Moeller sometime about 1875.[1] Although the total reduction does not reach that obtained by Goldberg, the achievement is still quite remarkable. Moeller's first slide is a reproduction of a banknote and the size of the microphotograph is 1.4 × 2.1 mm. The second one reproduces an engraving reduced to 1.3 × 1.6 mm, while the third one shows a newspaper page reduced to 1.9 × 2.5 mm, the total reduction in the latter being about 500 diameters.

[1] From a demonstration presented at the International Meeting of Forensic Pathology, Brussels and Ghent, Belgium, July 20 and 21, 1957.

Occasionally the view is still expressed that microphotography, though amusing in itself as a hobby, lacks actual importance. It played an important role in the wars of 1870 and 1940, a fact which microscopists engaged in forensic work

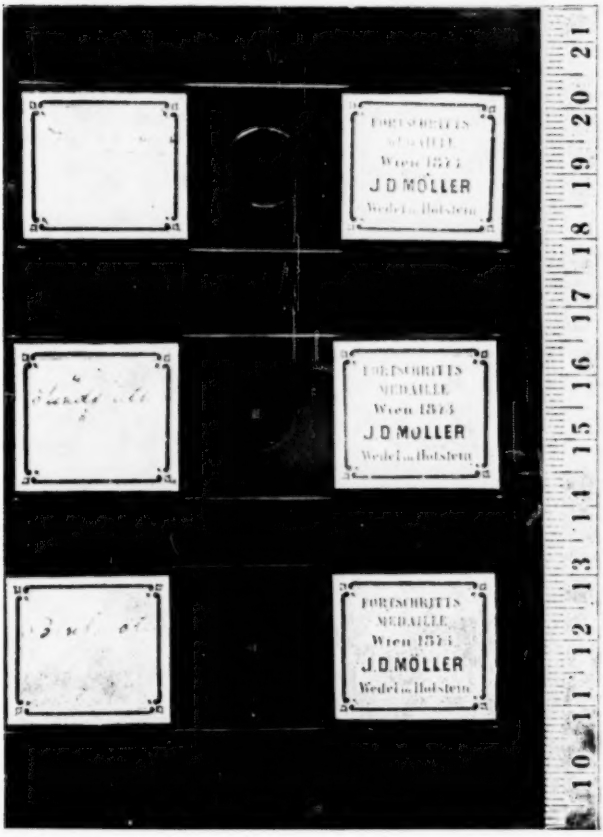


**Fig. 1**—Three slides of historical interest. They were prepared by Moeller as far back as 1875.

should keep in mind. Furthermore, it should not be forgotten that it was the forerunner of the high-reduction document photography now currently in use for the storage of archives

Fig. 2—Overall view of the microphotograph of slide 1 representing a newspaper page. (Photomicrographic magnification = 42 x.) In this, as in the following photographs, one graduation of the scale = 10 mu.

and the transmission of bulky documentation. Microphotography is moreover a method (and one offering many advantages) of making graticules (often called reticles in the United States) for a wealth of optical instruments such as theodolites, micrometers, gun and bombsights, etc. Lastly, it offers a potential research tool which, as yet, has not received all of its deserved attention.

Readers interested in the latter applications of microphotography are referred to the recent writings of G. W. W. Stevens (10) and especially to his book (11) which covers the entire subject not only from the historical point of view and theoretical background, but also in its practical applications and potentialities.

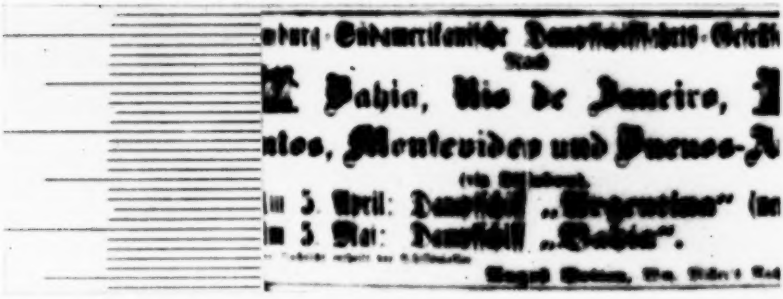

Fig. 3—Detail of the same microphotograph. (Photomicrographic magnification = 210 x.)

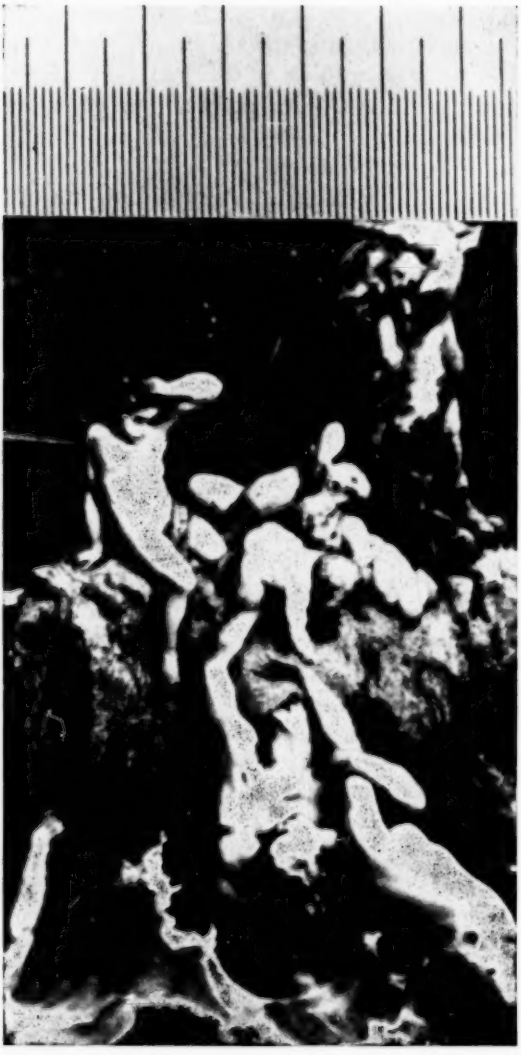

Fig. 4—Overall view of the microphotograph of slide 2 representing an engraving. (Photomicrographic magnification = 112 x.)

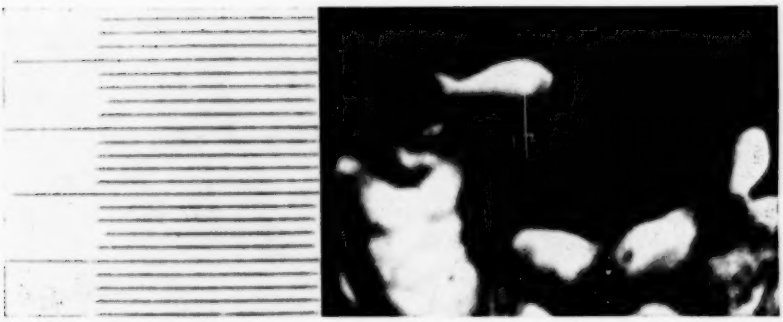

Fig. 5—Detail of the same microphotograph. (Photomicrographic magnification = 320 x.)

Fig. 6—Overall view of the microphotograph of slide 3 representing a banknote. (Photomicrographic enlargement = 45 x.)

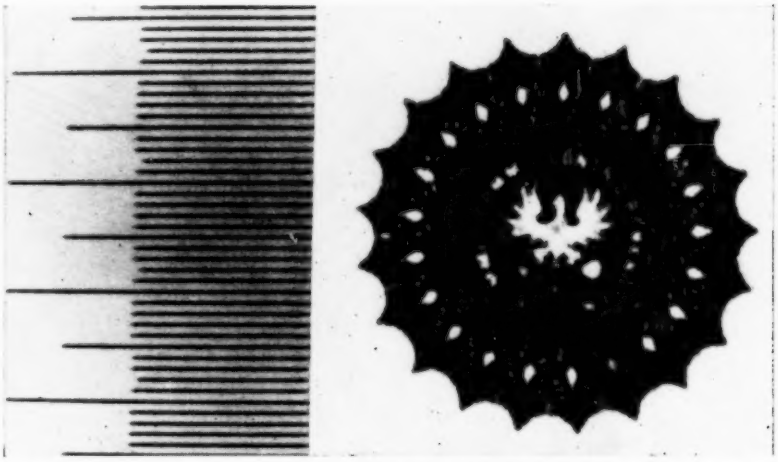

Fig. 7—Detail of the lower left corner of the same microphotograph. (Photomicrographic magnification = 175 x.)

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Laboratory of Criminalistics
University of Ghent
Ghent, Belgium

# A Microchemical Procedure for Paint Chip Comparisons*

*Friedrich Klug, Dipl. Math., Otto Schubert, Ph.D., and Livio L. Vagnina, B.Sc.***

The analysis of paint fragments of near-microscopic size, ranging from a few hundredths to a few tenths of a milligram, challenges the resources of the criminalist. As the samples become smaller techniques demand more sensitiveness and exactness. The forensic literature speaks glowingly of spectrographic methods because they are rapid and accurate in detecting elemental traces. Some workers, however, find the cross-section comparison of Burd and Brewer (1) superior to the spectrographic approach. The usual microchemical methods for the identification of paint chips are very difficult and laborious (2). A more exacting microchemical technique was required to confirm microscopic and instrumental methods of analysis. The present report describes a new microchemical method tested and currently used at this crime laboratory.

## Discussion

The results of spectrographic analyses may be doubtful, if, for example:

A. no characteristic elements are present; the quantitative results may be influenced by different thicknesses of the layers,

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** U. S. Army Military Police Crime Laboratory, Frankfurt/Main, Germany.

B. the paint layer contains organic dyes only and no inorganic compounds,
C. two adjacent layers of the same shade of color but different in their chemical composition are present,
D. traces of sand, rust, metal scrapings, etc. are present.

Spectrographic analysis is a summation of elements present in all layers and two chips of different layer composition could have the same summation results. Again, if several layers are examined together spectrographically the results do not show the composition of the single layers. In view of these limitations a procedure was sought which would complement and improve spectrographic and microscopic cross-section analysis. At this laboratory the authors have had highly satisfactory results utilizing the characteristic color changes undergone by different layers when subjected to a variety of chemical reagents. Although this method does not seek primarily to establish the anions or cations of the pigments, such a determination may be made when the examiner becomes sufficiently proficient.

A single layer of paint generally consists of three things: the color pigment, the binder (nitrocellulose, alkyd resin, etc.), and sometimes other substances such as metal powder, mica, and other silicates. The color pigments consist mostly of inorganic compounds of various chemical composition; organic compounds are present in some instances. A paint called silver-gray, for example, is a mixture of white, chrome oxide green, ferric yellow, and black. Now, if any of these four pigments reacts with a chemical reagent, the color of this layer will be changed and the resultant color will be dependent upon the percentage of the reacting component for its intensity. And when one compares two layers of paint, the same color will develop if the pigment components are the same—presuming that there is the same concentration of reagents, the same reaction time, and the same temperature.

Significantly, the larger the number of components of a paint, the greater the possibility that one of them will react. Generally, a paint chip to be studied is composed of two or more layers, and one of the samples to be compared may be present only in a minute amount. The potential for color

change remains large, however, as different layers are utilized, even on a small amount of paint. Suppose, for example, it is desired to compare two paint chips with the same sequence of layers: white, white, and red. If both exhibits change their colors in sulfide solution to: white, brown, and dark brown, and if the shade of the two dark browns and the two brown layers is exactly the same, it is highly probable that in the second and third layers the concentrations of the same pigments are the same. On the other hand, if two apparently identical layers produce different color reactions, using the same chemical reagent, it is impossible for their chemical compositions to be identical.

**Method and Experimental Details**

Currently five (5) reagents have been found to be adequate for most color-changing reactions. They are as follows:

A. Ethyl acetate.
B. Stronger ammonia water (58%).
C. Concentrated hydrochloric acid.
D. Ammonium sulfide solution (half concentrated) or a 10% solution of sodium sulfide.
E. A 5% solution of silver nitrate in 20% nitric acid (3).

The following procedure has been used successfully: using two similar paint chips—separate each exhibit into five small pieces (preferably not smaller than one square millimeter) and place them in appropriately marked test tubes (Wassermann type). Add the above-mentioned reagents to the tubes, not in excess of ten drops to each tube. Stopper the tubes with corks. Observe under the stereomicroscope. After allowing the paint chips to stand for about two hours, observe again under the stereomicroscope. Note the color changes which have occurred. Sometimes, particularly with blue paints, it is preferable to let the paint chips stand overnight in the reagents. Besides color changing, it is helpful to observe other effects that occur occasionally. These include development of gas bubbles in acidic solution (with reagents c and e); shrinkage, swelling or rolling; decomposition and stripping of layers; the growth of bumps in a layer, etc.

## Observations

The ethyl acetate test is helpful to determine whether nitrocellulose is present and to determine in which layer. If diphenylbenzidine reagent (prepared by dissolving 0.25 gm. of diphenylbenzidine in 100 ml. of chemically pure sulfuric acid) or similar organic compounds are used to test for the presence of nitrocellulose, it is best to test a few drops of the ethyl acetate solution with these reagents. Some ferric compounds (as found in red paints) and other oxidizing substances may show an intense blue reaction if diphenylbenzidine is used directly on the paint particles. The ethyl acetate solution is of further value when organic pigments are present. Because these colors will be soluble in the reagent, further comparisons can be made spectrophotometrically as well as with chemical reagents. The degree of color change by chemical reagents may vary widely in different cases; no hard and fast rule can cover all occasions. This is logically explained when the chemical composition of the pigments is considered. Although in some cases the changing is marked (as a dark blue layer may become light brown or green with ammonium hydroxide or hydrochloric acid; a white or gray paint may turn a dark brown, etc.) certain pigments are highly resistent in color change. In the latter category are included chromium trioxide, barium sulfate, titanium dioxide, carbon black, etc. In cases such as these, the stereomicroscopic observation of the reaction of the paint scrapings in concentrated sulphuric acid, concentrated nitric acid, and approximately 30% sodium hydroxide on a spot plate can be used to good advantage; further microchemical tests can be used to determine the type of binder.

## Advantages

The advantages of color changing methods are as follows:

1. No separation of layers is necessary.
2. Impurities and differences in layer thickness do not interfere.
3. Each layer can be tested separately.

4. Often layers are made visible that cannot ordinarily be seen, and the fine structure of a layer may become adequately visible for accurate comparison.

By utilizing this method it was possible for the authors to prove the identity of two seven-layered paint chips; in this case by microscopic examination the very thin surface layers were similar in color, but not in texture and the six lower layers showed marked differences. The color changing method established the surface layers to be the same. After careful microscopic examination one very small particle was found which showed the changing of the different layers beneath the top layer. Color changing tests verified the chemical identity of the lower layers.

Both the spectrographic and color changing methods have a definite place in the comparison of paint samples. Experience has shown that the color changing method should be carried out to supplement cross-sectional examination and spectrographic analysis.

This laboratory is continuing to investigate the potentialities of this method with still other reagents and under other conditions.

**Spectrographic Technique**

After paint samples have been examined microscopically and tested for their chemical activity with the reagents mentioned above and all pertinent data recorded on work sheets, spectrographic analyses may be performed. An ARL (Applied Research Laboratories) 1.5 meter grating spectrograph with an ARL Multisource unit as the excitation source and an ARL comparitor-densitometer is used at this laboratory. Experience has shown that the best conditions for the spectral analysis of paint particles utilize a DC arc with secondary voltage of 300 V, 50 microhenries, 60 pf, 35 ohms, and a current of 6.5 amperes. Ultra high-purity graphite electrodes (United Carbon quality) 0.25-inch diameter are used and burning time is 12 seconds. Eastman Spectrum Analysis film #1 is used and is developed in D-19 at 20 degrees Centigrade for 2 minutes in an ARL developing machine.

## Conclusions

Paint examinations are reported in three categories as follows:

1. Non-identity which constitutes negative proof.
2. Indeterminate conclusions—includes all those cases in which an accumulation of characteristics indicates similarity, but the facts are not quite sufficient to support a definite conclusion.
3. Identity in the form of certainty is considered to be established when six or more layers of paint, layer for layer, are in complete agreement in color, texture, layer sequence, chemical reactivity, and elemental composition.

## Summary

Because spectrographic analyses of paint samples are not always conclusive and have certain disadvantages a procedure was sought which would supplement spectrographic analysis. A new microchemical method for the comparison of paint chips is discussed and explained in detail and its advantages given as applied to experience with hit-run investigations. Applications may also be frequently made in connection with burglary and other sources of paint transfer including paint from buildings, safes, etc. Further research on this method is in progress.

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Livio L. Vagnina
U. S. Army Military Police, Crime Laboratory, Frankfort/Main, Germany
APO 757, New York, N. Y.

# Certain Interesting Aspects of the Evolution and Function of the Psychiatrist in Bench Consultation*

*Robinson Everett, A.B., L.L.B.,** and R. Burke Suitt, M.D.,****
*Perry Point, Maryland*

In the process of terminating a venture spreading over a 20 year period one of us has, a few months ago, surveyed the conditions encountered in a group of patients occasioning psychiatric study for the specific purpose of providing testimony about each of them in the form of a Bench Consultation. A casual inspection of the results of this survey necessitated the conclusion that the volume and complexity of the material denied condensation into a single report. Accordingly, a preliminary paper (1) opened with an account of the purposes, practical adjustments, and the procedures adopted in the pursuit of this particular type of psychiatric practice was tendered. The second portion of this article dealt with the clinical, social and economic conditions, and the channels of referral of the 132 patients concerned. This total embraced 20 females, 110 males and 2 persons of uncertain sex. The individuals ranged in age from 5 to 91 years. Each group of psychiatric disorders recognized by the 1952 Standard Nomenclature of Disease was well represented in the diag-

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** Visiting Associate Professor, Duke University School of Law, Durham, North Carolina.

*** Chief, Psychiatric Consultation Service, Veterans Administration Hospital, Perry Point, Maryland.

noses reached. Diagnostic groupings displayed a minimum conformity with the types of legal charges, with the sexually deviate approaching the only single exception. This essentially descriptive treatment of a pair of major themes was strengthened with case reports illustrative of the psychiatric malady, and the general dimensions of the court issues and the allied problems of communication to the judge and to the court.

The scope of the initial paper summarized in the foregoing neither undertook to assess the value of the Bench Consultant's work, nor did it reflect any systematic investigation of the clinical condition of the individuals concerned at a time much later than the examination required for the purposes of the Court. These two related and significant results merit a separate report, to be compiled at a future date. This proposed supplement will, like the initial paper and this present report, share one inescapable disadvantage. The legal aspects center, with few exceptions, in the system of courts and laws peculiar to a single state, namely, North Carolina. At the onset, it must be recognized that to some extent the expert's experience will vary according to the procedure and judicial structure in the locality involved. For instance, one of the difficulties involved in North Carolina is that under its unique system of rotation of judges, the judge who tries a case is frequently not the one who has heard pretrial motions in the cause, and so one judge might request that psychiatric testimony be secured and the psychiatrist might testify later before a different judge.

Similarly the problems of utilization of psychiatric testimony—or, for that matter, other expert testimony as well—will hinge on the extent to which the jurisdiction in question emphasizes the right of trial by jury (2) and the extent to which a judge is allowed to comment on the evidence. Thus, in some states contests as to the probate of a will—including the determination of the testator's competency—are heard solely before a probate judge or surrogate without a jury. Elsewhere the issue of proper execution of a will, including the testator's competency, is transferred to a jury for determination. In a Federal court, and in some state tribunals which follow the English common law view, the trial judge

is given extensive power to comment on the evidence; in many State courts, on the other hand, the judge is restricted and can only summarize the evidence, rather than intimate his views concerning its weight. Since the judge, by reason of his professional status, educational background, and more extensive experience, will usually be better qualified than the typical juror to appraise the weight of psychiatric testimony, it is apparent that the procedural matrix will make quite a difference as to the scope and importance of psychiatric evidence in the courtroom. Of course, where the judge has extensive powers with respect to the trial, and where he has also requested the psychiatric examination, it is clear that the psychiatric testimony of the court-appointed expert will be almost conclusive on any issue where mental capacity or responsibility is involved.

One other matter of procedural significance is the manner in which the expenses of psychiatric testimony are allocated. American courts, unlike their English counterparts, have a restricted view of the costs which are to be borne by the losing party. For example, in England attorneys' fees are assessed, subject to judicial control, as part of the court costs; while in the United States, with a few statutory exceptions, such as in copyright cases (3), and a few judicial exceptions recognized in some states, such as a bona fide contest concerning the probate of a will (4), attorneys' fees do not constitute part of the court costs. Fortunately, provision is made for the allowance of expert witness fees, which are payable as part of the court costs by the losing party. Yet, in this arrangement, there are several disadvantages, apart from the obvious one that the fees are frequently not high enough to compensate adequately the qualified expert for the torture that he may undergo in the courtroom. One main disadvantage is that a party loses the chance for reimbursement of the witness' fee, unless he call the expert to the stand and thereafter wins his case. For the impecunious participant in litigation this barrier to the use of expert testimony may be quite significant.

In criminal trials the problem for the defendant is especially severe. He may be incarcerated prior to trial and without either funds or the opportunity to obtain them. Many

a psychiatrist, hard-pressed for time, will not wish to leave his office and examine the accused in his place of confinement; and the burden of arranging to have him brought to the doctor's office may be quite a heavy one. Of course, in a criminal case where there is serious doubt as to mental competency to stand trial or mental responsibility for a crime, the examination of the accused by a good psychiatrist may be even more important than the right to counsel; and yet some courts which pride themselves on appointing counsel for indigent defendants exert themselves much less to assure that a psychiatric examination is made of the defendant, even in cases where the desirability thereof is clearly indicated.

Circumstances such as these have led to a developing body of opinion to the effect that provision should be made for psychiatrists and other expert witnesses to appear as "friends of the court," witnesses testifying in response to an invitation from the bench rather than at the urging of a party. In this role of court witness, rather than witness for a litigant, the expert would be better situated to demand, and obtain, protection from the court against the badgering and harassment by counsel which is often too prevalent in today's courtroom. Furthermore, as a custom developed of judicial appointment of expert witnesses, some steps, it has been suggested, could be taken better to allocate the expense of the expert. Indeed, some informed persons have intimated that, with the cooperation of appropriate associations of experts, such as the various medical associations, the burden of presenting a report to the court might be undertaken by the expert at very low expense—indeed, virtually as a public service. Of course, the premise here is that, in the proposed judicial milieu, the task of presenting a report would be a relatively simple one, for, as a court witness, the expert would be virtually immunized from extensive cross-examination.

The criticism of proposals for the widespread use of court-appointed experts has been premised in large part on the adversary tradition of Anglo-American jurisprudence, a tradition quite different from that of those countries in Europe and elsewhere which derive their jurisprudence from Roman Law and the Napoleonic Code. Furthermore, in those American jurisdictions where the distrust of judicial power is so

great that the judge is not allowed even to comment on the weight of the evidence, it might be somewhat incongruous for a judge to have the opportunity to appoint an expert to testify in the cause—and by such appointment invest the expert with that mantle of authority and respectability connected with the juror's image of the judge, and also divest the expert of any association with the assumed self-interest of the litigant. As to fields like medicine or psychiatry, where there have been—or at least so the general public and many lawyers believe—several conflicting schools of thought as to certain problems of forensic importance, the critics also have asked what safeguard there is against judicial appointment of an expert who, while not a partisan of a particular litigant, is a partisan of some esoteric and little-accepted theory. This argument has been urged with special vehemence with respect to psychiatric testimony as to mental responsibility because of the alleged divergence of theory among experts (5), and the alleged tendency of a few psychiatrists to use psychiatric terminology to cloak fundamental ethical or social evaluations.

If a judge or clerk of court does not appoint an expert to render a report as a "friend of the court," one procedural question of some importance still remains. At any trial or hearing which follows the preparation of the expert's report, will the judge himself call for the presentation of the report or testimony from the witness, or will one of the parties—presumably the one whose position the report favors—call the expert to the stand? In theory, this might become important even if the hearing were conducted solely before a judge and with no jury present, for the restrictions on impeachment of a witness by cross-examination and otherwise are usually affected by whether the party seeking to impeach the witness has himself tendered the witness to the court and thereby vouched for his reliability (6). Also, the use of leading questions is affected by whether the interrogator has called the witness to the stand (7).

However, of far more importance is the situation that exists where the trial is held before a jury. There, if the judge calls the expert to the stand, he may be considered by the jury to have indorsed the witness' credibility and ability.

This implicit indorsement might be—or so some attorneys think—a significant factor in a close case where the evidence was very much in conflict. Should the judge not call the expert to the stand of his own motion and thus one of the parties has to do so, then obviously his counsel will wish to "associate" the witness with the judge in the jury's mind and thereby (a) gain the benefits of any enhanced weight that may be given to the witness' credibility as a result of this association and (b) dissociate the witness from the party who called him, and thereby from any suspicion that his testimony might be influenced by such sordid considerations as payment or expected payment of a fee.

This goal of the counsel who has brought the witness into court will be pursued by questions to the witness concerning the circumstances of his appointment by the court. And frequently these questions will produce objections from opposing counsel. Against this procedural and tactical backdrop, the expert will often find himself confronted with a major problem of proper courtroom behavior—i. e., how far should he go in volunteering information and answering questions nonresponsively, in order to emphasize to the judge, and more important to the jury, that he is not interested in the case's outcome and would not be in court save for a duty which he felt was imposed upon him by conscience in light of his appointment as a "friend of the court." How that problem *should* be resolved is not subject to an answer in this paper; but it is clear that not a few experts, psychiatrists among them, feel that in self-defense they must clearly and repeatedly assert their impartiality, as demonstrated by the circumstances of their appointment. Altogether, there still remains a large area for exploration concerning the position of the psychiatrist who testifies as an expert witness (8), either as an impartial "friend of the court" or in the acknowledged interest of defense or prosecution.

From the common law, the age at which an individual first becomes answerable to the charge of murder has been a vexing item. The advance of time has been marked by palpable changes in the members of the bar, as well as among those in other professions, and in the body politic, in dealing

with any child or adolescent determining the death of another person. While this benevolent trend doubtless asserts the finer elements in human nature, the technical problems in law and in medicine are advanced here through the survival of the killer and the resulting opportunity to understand his act and to rectify the morbid processes culminating in the deed or to fail in the undertaking of one or both of these goals.

The child who openly and deliberately kills a parent without objective provocation now challenges both court procedure and psychiatric classification far less than the tragic event defies easily followed and cogent explanation.

The next sequence illustrates one version and outcome of this problem. Several years ago a girl of 14 years approached her father from behind with a shotgun, discharged the weapon, and he died on the spot. The newspaper accounts detailed her composure while she proceeded to tell, in a matter-of-fact way, of planning the shooting while she was preparing to go to church earlier in the same day, loaded the weapon only to decide against discharging it upon her father in the yard for fear of accidentally killing others with him there, and delaying firing until he had returned into the house and was there alone. She explained her act by telling of her resentment, undisplayed, at her father's requirement that she do ordinary chores in the maintenance of the household, including washing dishes. Those who had known her long and well furnished reporters with ample information to the effect that she was a good student, a likeable girl and never a problem in the classroom or elsewhere in the community. The Juvenile Court judge ordered the girl transferred to a higher court, and without bond. The judge of this court and the prosecutor, coordinated with the defense attorney in ordering a pre-trial psychiatric examination. The calibre of responsibility and judgment entailed were reflected in the careful arrangements for the patient to be brought more than 100 miles distant in the company of a matron and a deputy in order to secure this examination under ordinary office conditions. So upon its completion the fact that the examination had been made was announced but no intimation whatever regarding the place and the people involved in conducting the examination escaped to become public knowledge, despite an

abundance of pressures from the press and others with vested interests in the daily news.

The result of this initial psychiatric examination was unclear. The differential diagnosis lay between a catathymic crisis operating independently and the same mechanism introductory to an imminent overt schizophrenic reaction. This uncertainty was candidly shared with the judge, along with the recommendation that the patient be admitted to a psychiatric hospital for a minimum of 30 days for observation and further study. This recommendation was implemented as early as a suitable bed could be found. Within a matter of days unmistakably schizophrenic manifestations appeared. These included auditory hallucinations involving the dead father's voice. Despite excellent treatment and management, little colored by the events bringing the girl into prominence and into the hospital, her interval course there has shown the usual unfavorable trend of schizophrenia appearing so early in life. The charge was never heard and the existing condition of the patient augers against any formal requirement of a court disposition at some future date.

In this situation the psychiatrist's first major function is to identify a fully exculpatory mental condition as sufficiently probable to warrant delay and detailed study and observation. Fortunately, neither courts nor society more generally require him to display in evidence the reasons for the development of such a disorder and the way in which such a disorder contrives to carry forward, over almost ten years, the vengeful wrath of a little girl directed at her father. She had been, as a tot, quietly incensed that he shot the wild squirrels whom she regarded as friendly playmates. Cleaned of shot, and tastefully prepared, their bodies brought to the table as food were dishes for which she had no relish. Helping to remove the dishes upon which the bodies had been served, and receiving practical instructions in the way in which to wash the dishes, added to the storage of wrath. It is far easier to understand why this led to the father's death with the selfsame shotgun than to decipher the timing of this event and to relate it to the evolution of a progressive mental disease. But such abundance is not to be expected from 20 minutes in an examination running but an hour and a half.

In passing from this individual case extract certain comments are indicated. These are germane to other cases which are not detailed, and which are similar but in part. First, the patient cited having passed her 14th birthday, was held pending a charge of first degree murder, as would have applied to an older adult. Successful, or merely attempted, killing appears more likely to arouse the question of mental disorder at the extremes of the adult age spectrum. But it is futile to speculate about those who are executed, as a result of trial and conviction, and reassuring to recall the reports about those who are merely sentenced. In the second place, it would be a callous psychiatrist who inquired about the operations of legal machinery when all concerned simply fail to complete charges against a juvenile killer. This benevolent disposition actually applied to a 14 year old boy instrumental in his father's death. Here the examination evidences for a catathymic crisis was quite incomplete, and neither the examination nor time indicated a schizophrenic concomitant. But it is far easier to accept such a benevolent leverage upon the scale of justice than to digest the opposite. Such an opposite is exemplified in talking about the social remission resulting from five years of treatment of a paranoid schizophrenic reaction in a young male patient. He requested a hearing upon a double murder charge, pending from the time of his commitment. The hearing of the charge of first degree murder ended in mistrial. A second hearing terminated with his conviction for second degree murder. The attitudes aroused in the four psychiatrists testifying, all having participated in his treatment, have been considerably offset by the equable adjustment which the patient has made while in prison, under the watchful care of a fifth psychiatrist. And finally, there is the unpopular, but not illogical position, that this young man, and the 14 year old girl, were in neither instance, psychotic at the time of killing, but that each became so in the process of repudiating an overwhelming guilt-inspiring action. No doubt the practical need to determine the ability to cooperate in defensive legal procedures diverts attention from examining this possible sequence along more critical lines.

The dramatic qualities and enigmatic private world investing almost every instance in which one person kills another are not likely to be duplicated in controversies concerning competency. Tangibles here allow the psychiatrist to correctly confine his attention to this single issue in his testimony, even though his examination would allow extension into other related opinions.

A second case is of some interest because it highlights the oft-remarked dichotomy between legal and medical criteria for competency and responsibility. A widow had been duly committed to a mental hospital in another state, and her considerable estate there placed under guardianship. The staff of the hospital were so satisfied with her clinical improvement as to "parole" her at the end of several weeks of simple conservative treatment. Under these circumstances she returned to North Carolina to visit with members of her family. Unable to secure prompt or definite action respecting her material needs from her guardian, she consulted an attorney. Correctly apprehending that she was mentally ill, but not incompetent, he referred her for psychiatric opinion, restricted to competency. The certificate indicating an opinion that she was "now fully capable of independence in her daily life and entirely competent to manage her material affairs and estate" made no allusion to her paranoid state. Whatever of this latter may have been sensed by a special jury, this body's findings agreed that she was competent, and she was so adjudicated by the North Carolina court hearing the petition. Since there was doubt that this determination would be binding in the courts of the committing State, or that she would be able to secure from her guardian the substantial funds that were in his control, it was determined to arrange for a hearing in that other State concerning restoration to sanity. Because of the procedural rules of that State, it was essential to supplement the deposition testimony of the North Carolina psychiatrist with the in-court testimony of a local expert. This doctor, a man of considerable experience, examined her on the morning of the hearing and somewhat shocked her counsel by commenting at once that she was "crazy as hell." However, he promptly added that so far as the legal criteria of competency were concerned, he would have to testify that she

was legally competent. At the hearing he did, in fact, testify as to this legal competency; and, since no one raised the point whether she was suffering from "mental disease" of any sort, a decree was entered restoring the patient to competency.

There is much to suggest that when two individuals are affected with a paranoid folie á deux their unity of belief claims public attention far longer than would be true of a single person deluded in the same way. This seems to circumvent general recognition of the true situation in the community, and to foster protracted painful consequences upon target individuals and a staggering neglect of property. While the diagnosis of folie á deux is unhallowed by the 1952 Standard Nomenclature of Disease, it can nevertheless be accurately applied to the two patients among the principals of a third legal case.

This involved a slander action in which the defendants were two elderly spinsters who lived in a large dilapidated home. Because the nature of their alleged slander was quite extraordinary, the defendants' counsel asked that a psychiatric report be made on the two sisters, and, after an order was obtained from the Clerk of the Court directing that such a report be made, the two sisters were evaluated, and the examiner discovered the existence of a folie á deux paranoid schizophrenia.

To counsel this report seemed significant for several reasons: (a) It negated the existence of a state of mind which would justify the punitive damages that the plaintiff was seeking; (b) it possibly negated the existence of that "malice" which some courts have stated is an essential element in a cause of action for slander; (c) it raised substantial questions under North Carolina law concerning certain evidence that the plaintiff planned to use (9).

The trial judge was, of course, not the person who had signed the order directing a psychiatric examination in the first place. And, besides, under North Carolina law the powers of a judge in connection with a trial are relatively limited. Therefore, either by reason of choice or a feeling that he lacked power so to do, the trial judge was unwilling himself to call the expert to the stand. Thus, he was called as a witness for the defendants, whose counsel did, however, manage

to bring out in the course of the testimony that the examination of the defendants had been pursuant to an order of the court. The cross-examination did not produce substantial clarification of the testimony initially given by the witness, but fortunately the jury comprehended the evidence well enough to refuse punitive damages and to award compensatory damages far below those claimed. Subsequently, the case was settled prior to appeal.

While the order of the Clerk of the Court had been initially made at the instance of one of the parties and not as a result of any agreement between counsel, it did afford some aid to the expert witness in resisting the onslaught of the cross-examiner, and did enable him to assert his nonpartisanship more convincingly. Also the appointment of the expert by court order to examine the defendant assisted counsel in their evaluation of the testimony in the course of argument. However, in all candor it must be admitted that the attorneys for the two defendants might have hesitated to have asked for a court order authorizing and directing a psychiatric examination of their clients had they not been relatively sure of the outcome of any such inquiry. Furthermore, since there was no well-defined statutory procedure in North Carolina for the appointment by the court of a psychiatric examiner in a contested case of this sort, the status and legal effect of the order for a psychiatric examination of the defendants were shrouded in uncertainty throughout.

This paper cannot seek to determine how far apart are psychiatry and the law. Those who have noted the reluctance of other tribunals to follow the test laid down by the Court of Appeals for the District of Columbia in the Durham (10) case will recognize readily that the bar is by no means ready to swear allegiance to psychiatry and its teaching (11). There is no doubt, however, that the psychiatrist who goes into court—whether as a witness for one of the parties or as a "friend of the court"—must be prepared to answer to the best of his ability those questions that are significant for legal purposes. Of course, as any psychiatrist knows there are many questions to which the courts attach great weight, which are meaningless psychiatrically—unless heavily qualified and explained. For instance, the old inquiry "Did he

know right from wrong at the time of the act and with reference thereto?" is subject to considerable qualification and amplification as to the meaning of "know."

Yet if the psychiatrist or other expert fails to face up to the fact that the typical lawyer or judge is a pragmatist interested in getting his work done in a fair and expeditious way, rather than in hearing extensive medical discussion, he will find that his time and testimony are completely wasted. While the expert witness does not wish to engage in legal quibblings, he must have some knowledge of the germane legal issues, or else he will find his testimony excluded, stricken, or ignored. For this reason the psychiatrist will find it important to discover from the judge or the attorney who is requesting the psychiatric examination exactly what the relevance of psychiatric evidence is to the legal problems at hand. Once possessed of understanding in this regard, he will frequently find ways of communicating to the judge and jury the information which he considers most significant for the resolution of the case. Indeed, usually this information can be communicated in the course of explaining the basis for the opinions that the expert is called upon to give. Possessed of this information the psychiatrist identifies the facts to be established in respect to the legal need and the rationale for their employment. Accepting participation in the problem implies, at the same time, an obligation to form opinions regarding each item about which testimony may be needed.

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Veterans Administration Hospital
Perry Point, Maryland.

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## CERTIFICATE IN FORENSIC PATHOLOGY

The American Board of Pathology is now considering applicants for certification in the special field of forensic pathology. The Board, in collaboration with the Council on Medical Education and Hospitals of the American Medical Association, is also accepting applications from institutions that are seeking approval of programs for training in the special field of forensic pathology. For information, please write to the Secretary, Edward B. Smith, M.D., American Board of Pathology, Indiana University Medical Center, 1100 West Michigan Street, Indianapolis 7, Indiana.

TECHNICAL SECTION

# Toxicology of Some New Drugs: Glutethimide, Meprobamate and Chlorpromazine*

*Elvera J. Algeri, B.S., George G. Katsas, M.D., and Arthur J. McBay, Ph.D., Boston, Massachusetts*

As the list of tranquilizing agents and sedative drugs continues to increase, so do the problems of medicolegal investigators. However, many of the new drugs being synthesized have the same basic structures as the original classical compounds. Thus, the task of recognizing these compounds in medicolegal cases is not so formidable as might first appear.

This report presents the results of a partial review of the voluminous literature regarding glutethimide, meprobamate and chlorpromazine, three of the most commonly used newer drugs, and includes (a) methods of detection and quantitation of these three agents; (b) the metabolic fate and excretion of these agents; and (c) cases involving ingestion of these drugs in amounts greater than therapeutic doses, including, when possible, probable amounts ingested and pertinent clinical histories. The therapeutic uses, pharmacology and side-effects of these drugs are beyond the scope of this paper and have been adequately discussed elsewhere (1–12).

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## Glutethimide (2–ethyl–2–phenylglutarimide) Doriden ® [1]

*Methods of Determination:*

Two methods for the determination of glutethimide in biological materials have been reported. The first method is that of Sheppard and co-workers (13), a lengthy procedure requiring about two days for the complete analysis. Since only a small fraction of unchanged drug is excreted in the free form, it is better to determine the total metabolite, 2-phenylglutarimide in urine. Although these authors report possible quantitation of the drug in blood, we have been unable to find either the drug or metabolite in blood or liver by following their procedure. However, the method allows easy detection of the metabolite in the urine following one-gram doses of the drug, and for this reason is useful in cases of suspected massive ingestion of glutethimide. The urine is hydrolyzed and then extracted with benzene. This extract is poured over an alumina column. After elution and evaporation of the eluate, the residue is dissolved in methanol. An aliquot of this solution may be quantitated using the ferric chloride reaction with the hydroxamic acid derivative. Using another aliquot, paper chromatographic analysis may be applied.

The second method is that of Goldbaum (14). This method takes advantage of the hydrolysis of glutethimide in alkaline solution. Serum or urine is extracted directly with chloroform; then the chloroform phase is washed, first with base and then with acid, both of which are discarded, and the chloroform solution is evaporated to dryness. The residue is dissolved in ethanol and potassium hydroxide solution added. The alkaline hydrolysis is observed by following the decrease in absorbance at 235 mu with time and is usually complete at the end of one hour. By extrapolation, the amount originally present may be calculated. It is not possible to apply this method to hemolyzed blood, and the method does not appear to be useful for the analysis of kidney or liver.

Huisman and Bosch (15) have also observed the rapid hydrolysis of glutethimide and noted that a barbiturate antagonist, 3-methyl-3-ethylglutarimide (Methetharimide, Megimide) has a similar maximum absorbance in alkaline solution. They found that this compound is also hydrolyzed but at a much slower rate than is glutethimide. Curry (16), who commented on the instability of the glutarimide ring, has outlined a method for the elimination of interference due to Megimide by heating an alkaline solution of the compound when it is wished to determine barbiturates by ultraviolet spectrophotometry.

We have found that modifying the method of Sheppard and co-workers by replacing the hydroxamic acid reaction with the spectrophotometric procedure of Goldbaum gave satisfactory results for determination of the drug in urine.

Bernhard and co-workers (17) using rats given $C^{14}$-labeled glutethimide found that 75% of the activity is excreted through the bile and the rest through the kidneys.

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[1] Ciba.

## *Toxicity:*

The toxicity of glutethimide has been reviewed recently by McBay and Katsas (18). They found that the greatest amount of the drug ingested with recovery was 15 grams, and the smallest amount reported to have caused death was 10 grams. Results of the study indicated that the lethal dose of glutethimide is from 10 to 20 grams. Autopsy showed no characteristic findings. Pulmonary congestion and edema were noted in all cases.

TABLE 1

Analysis of Serum for Glutethimide

| Hrs. Dialysis | Arterial | Venous |
|---|---|---|
| | Mg. of Glutethimide per 100 ml. | |
| 0 | 1.7 | – |
| 1 | 1.4 | 1.2 |
| 3 | 1.3 | 0.8 |
| 6 | 1.0 | 0.7 |
| awoke next day | 0.4 | – |

Analysis of Urine for Glutethimide

| Sample [2] | Metabolite of Glutethimide | |
|---|---|---|
| | Mg. per 100 ml. | Mg. Recovered |
| 24-hr. urine prior to dialysis | 16 | 22 |
| 3 hrs. after start of dialysis | 91 | 9 |
| Last ½-hr. of dialysis | 43 | 12 |
| 0–24 hrs. after dialysis | 8 | 14 |
| 24–48 hrs. after dialysis | 8 | 58 |
| 48–72 hrs. after dialysis | 2 | 48 |
| 72–92 hrs. after dialysis | 1 | 2 |
| 92–108 hrs. after dialysis | 0 | 0 |

## *Additional Cases:*

A 23-year-old female was reported to have consumed thirty 0.5-gram-tablets of Doriden and lay in coma for 2½ days receiving only caffeine. Since there was no apparent improvement in her condition, hemodialysis was employed.

Serum and urine obtained before, during and after dialysis were analyzed in this laboratory. The urine specimens were hydrolyzed and processed using the method of Sheppard and co-workers, and quantitation was accomplished by the hydroxamic acid reaction as well as the spectrophotometric procedure of Goldbaum. Results with both methods were essentially the same. Paper chromatographic analysis showed that only the metabolite was present. Serum was analyzed by the technique of Goldbaum. It was not possible to use paper chromatography due to the small amounts of material isolated.

It was found that for the smallest sample of serum (2 ml.) the maximum absorbance at 235 mu was not marked, but the rate of hydrolysis was

[2] 100 ml. analyzed except for the samples of the 3rd hour and the last half-hour dialysis when only 10 ml. and 27 ml. were excreted respectively.

readily observed and followed. By tripling the amount of serum, the characteristic alkaline maximum was readily observed, and it is worthy to note that the results obtained with both quantities of serum duplicated each other in every instance.

The patient awakened the day following hemodialysis, but had tachycardia, disorientation and confusion for several days (Table 1).

TABLE 2

Summary of Cases of Glutethimide Ingestion [3]

| Sex | Age | Amount Gms. | Remarks |
|---|---|---|---|
| M | 33 | 1 | Therapeutic dose. Urine maximum 8 mg.% (12–24 hrs. after ingestion). |
| M | 37 | 1 | Therapeutic dose. Urine maximum 10 mg.% (15–22 hrs. after ingestion). |
| M | 38 | 5 | No coma. Recovery in 24 hrs. |
| F | – | 5 | Recovery after 36 hrs. coma. |
| M | 29 | 6 | 48 hrs. coma. Recovery after 5 days. |
| F | 31 | 6 | Recovery after 48 hrs. coma. |
| F | 24 | 8.5 | Recovery after more than 36 hrs. coma. Urine 15 mg.% (at least 30 hrs. after ingestion). |
| F | 39 | 10 | Recovery after 23 hrs. coma. |
| F | 23 | 10 | Death after 24 hrs. coma. |
| M | 23 | 12 | Death in less than 43 hrs. Urine 24 mg.%. |
| M | 20 | 15 | Coma 3 days. Recovery in 7 weeks. |
| M | 56 | 15 | Death in less than 24 hrs. Urine 34 mg.%. |
| F | 40 | 50 | Death. Urine 42 mg.%. |
| F | 33 | ? | Death in less than 4 hrs. Urine 48 mg.%. |
| F | 23 | 15 | Recovery after 3 days coma. Serum 1.7 mg.%. Urine maximum 3 hrs. after start of dialysis: 91 mg.%. |
| F | 52 | ? | Death in 12 hrs. Urine 21 mg.%. Plasma 17 mg.%. |

A second case, in which an unknown amount of glutethimide was ingested by an alcoholic, was studied in these laboratories. A 52-year-old female was found dead after last being visited by her physician the evening before. She had been drinking heavily at that time. Autopsy showed congestive heart disease and arteriosclerosis of the coronary arteries. Analysis for glutethimide yielded unchanged drug in the stomach. Metabolite only was

[3] These cases have been reviewed by McBay & Katsas (18) with the exception of the last two which are discussed here.

found in the urine which contained 21 mg. per 100 ml. The results of the analyses [4] of blood were as follows: 17 mg. of glutethimide per 100 ml. plasma (method of Goldbaum (14)); 0.3 mg. barbiturate per 100 ml. blood; no alcohol was found.

Table 2 is a summary of the known cases of glutethimide intoxication, as well as the two cases discussed above, and also includes the results obtained after the ingestion of therapeutic doses in two instances.

## Meprobamate (2–methyl–2–n–propyl–1, 3–propanediol dicarbamate) Miltown ®,[5] Equanil ® [6]

### *Methods of Determination:*

Agranoff and co-workers (19) have outlined a procedure for the colorimetric determination of meprobamate and applied the method to study the physiologic disposition of the drug in human subjects. The meprobamate in urine is extracted into ether at an alkaline pH. After evaporation of ether, the residue is heated with concentrated sulfuric acid. Water is added after cooling and the absorbances determined at 450 and 500 mu. A maximum is present at 450 mu, but by using the difference in absorbance at these two wave lengths for estimation of meprobamate present, interference due to substances which might normally be present is overcome. The procedure is outlined for extraction of 3 ml. of urine, and it is possible to detect as little as 2γ of drug. The authors have applied the method to blood and tissues by making a trichloracetic acid filtrate which is extracted after being made alkaline. The procedure is then the same as above. Unlike urine, recovery of the drug from these media was not found to be quantitative (20).

Alcohols with 4 or more carbons and no carboxyl groups interfere with the determination as will some compounds structurally related to meprobamate. However, the actual presence of meprobamate may be verified by subjecting aliquots of the dried ether extract to comparative distribution ratio studies using organic solvents and sodium hydroxide.

These authors also studied the urinary excretion using four human subjects who received 1600 mg. of the drug orally as a single dose. It was found that the drug was slowly excreted for two days and that 12% to 20% of intact drug was excreted in the urine. Further investigation of the urine showed that several conjugates are present including a compound presumed to be a 0-glucuronide. The authors also established the liver as the main site of metabolism.

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[4] Analyses by Frank Stratton.

[5] Wallace Laboratories.

[6] Wyeth Laboratories.

Berger (4) had previously reported that about 10% of the meprobamate was excreted unchanged and noticed an increase in the glucuronic acid excretion following ingestion of meprobamate which indicated the presence of glucuronide in the urine.

Ludwig and Hoffman (21) have devised a unique colorimetric method for the determination of meprobamate in biological fluids. It depends on the reaction between meprobamate and furfural in the presence of antimony trichloride. Urine or serum is extracted with ether which is evaporated to dryness. The residue is treated with an aqueous urease suspension in order to remove the urea which has been the only interfering component encountered by the authors. After incubation, the mixture is treated with phosphotungstic acid and sulfuric acid and the filtrate extracted with ether. The dried residue obtained from evaporation of ether is treated with glacial acetic acid. After addition of antimony trichloride followed by furfural, the absorbance at 570 mu is measured and calculation based on the results of 50$\gamma$ of meprobamate treated in the same way. The authors state that there is a linear relationship between absorbance at this wave length and concentrations of 100$\gamma$ meprobamate per final volume measured. Estimations of 10 to 100$\gamma$ of drug in extracts of urine or serum have been found practical. Other similar reagents produce like results, but the furfural and antimony chloride give optimum results with a minimum of interference.

Ludwig (22) has developed a procedure for the formation of the xanthydrol derivative of meprobamate isolated from urine which is useful for confirming the presence of the drug. An ether extract containing 2 to 10 mg. of drug is evaporated, dried and then treated with a mixture of glacial acetic acid and absolute ethanol. An appropriate amount of xanthydrol in the same medium is added. The crystalline product obtained after heating is isolated and may be crystallized from ethanol. Final identification is based on the melting point of this dixanthydrol derivative. Ludwig has successfully applied the technique to as little as 5 ml. of urine of humans and states that the lowest limit of usefulness appears to be in the range of 2 to 5 mg. meprobamate per sample with further refinements expected.

Walkenstein and co-workers (23) have studied the excretion and distribution of meprobamate and its metabolites using the $C^{14}$-carbamate-labeled drug. In the course of this work they also developed a colorimetric method for the determination of meprobamate in plasma and urine. Free drug is determined as follows: 1 ml. of urine or oxalated plasma is shaken for 1.5 minutes with 5 ml. ether in glass-stoppered tubes containing 400 mg. of anhydrous potassium carbonate for urine extracts, or 60 mg. of activated charcoal (Darco G 60) for plasma extracts. The tubes are shaken for 15 seconds and centrifuged. The ether is decanted into other tubes and evaporated in a water bath at 50° C. After addition of 4 ml. of color reagent (2 gms. hydroquinone in a mixture of 85 ml. of concentrated sulfuric acid and 15 ml. of water), the tubes are placed in a boiling water bath and after about 1 minute glass-stoppered, given a few shakes and allowed to

remain in the water bath for a total of 25 minutes. The tubes are then cooled to room temperature; the color is stable for more than 24 hours. The absorbance is determined by a colorimeter at 400 mu. A reagent blank is prepared by using 1 ml. of water in place of the sample. Greater sensitivity can be obtained by decreasing the amounts of color reagent added. Blank values for urine and plasma from dogs and humans were determined. As little as 2$\gamma$ per ml. of material tested can be determined. The authors claim specificity for meprobamate since hydroxymeprobamate, the major metabolite, and other substances including urea, alcohols and barbiturates do not interfere.

Using this method, the authors found that there is equal distribution of the drug between cells and plasma, but because of the high blanks encountered with whole blood, preference is given to plasma as the test medium. Oral administration of the labeled drug to dogs showed a maximum concentration (8.1 mg.%) in the plasma was reached 2 hours later with an average rate of decline from the second to the sixth hour equal to 0.7 mg.% per hour. Unchanged drug accounted for 50% of the total activity.

With dogs given the labeled meprobamate, orally or intra-abdominally, significant amounts appeared in the urine within half an hour with almost 90% of the dose being excreted with the first 24-hour period. Unchanged meprobamate accounted for about half of the total $C^{14}$ excreted during the first half hour for the group receiving the drug orally and the ratio fell to 10% by the sixth hour.

When 9 human subjects were given orally 1 gram each of the drug (unlabeled) an average of 0.66% of the given dose was excreted unchanged in the urine in the first two hours. The excretion rate doubled during the next two hours and so remained up to the twelfth hour. A little less than 7% of the dose was excreted unchanged at that point with an additional 2.5% appearing within the next 12 hours. About 11.5% of given meprobamate was excreted as such during the 48-hour period.

A study of the distribution of labeled meprobamate given to rats by stomach tube resulted in the highest activities for lung, kidney and liver, the drug being readily absorbed from the intestinal tract. The authors note a low rate of gastric emptying with this species after oral administration.

Radioautographs of paper chromatograms of extracts of urines of dog and rat after administration of labeled drug enabled these workers to distinguish 5 metabolites of meprobamate.

In Table 3 are reproduced data of Walkenstein and co-workers showing the urinary excretion products of meprobamate in dogs and the amounts excreted.

### *Toxicity:*

This compound is unique in that it is a simple aliphatic substance to which property is attributed its low toxicity. It is considered to be one of the safest drugs available, and is noted for its versatility in treating a wide range of emotional disturbances.

TABLE 3

Urinary Excretion Products of Meprobamate in Dogs

| Metabolite | Rf [7] | Identity | Amount Excreted % of dose |
|---|---|---|---|
| 1 | 0.8 | Meprobamate | 10–12 |
| 2 | 0.6 | Hydroxymeprobamate | 60 |
| 3 | 0.3 | Unknown | 1–1.5 |
| 4 | 0.06 | Glucuronide | 5–10 |
| 5 | 0.03 | Glucuronide | 5–10 |

The number of cases of suicidal attempts by ingestion of massive doses of meprobamate reported in the literature is remarkably low when one considers its widespread use, and it might be commented that the low incidence of cases is a reflection of its efficacy as a true tranquilizer.

Table 4 summarizes reports concerning 14 cases (24–33) of meprobamate intoxication resulting in coma and includes pertinent clinical data. Manifestations of intoxication have been markedly diversified. Coma has been observed after the ingestion of from about 6 to 38.4 gms. (47–550 mg./kg.), but in other instances similar amounts over a period of 24 hours have caused little or no serious effects (34). Collins-Dineen (29) and Shane and Hirsch (24) have expressed the opinion that massive doses might cause death. Such wide differences may be attributed to increased individual tolerance or loss of drug either by vomiting or by stomach lavage. Fatalities due to over-ingestion of meprobamate have not been reported. Lockhart (32) discussed a case where death occurred 77 hours after recovery from coma; however, the cause of death was due to pulmonary edema believed to be the result of over-hydration arising through treatment of circulatory collapse.

All of the cases presented are considered to be those of attempted suicide and all but one involve women. Most of the patients had some history of psychotic or emotional disturbances. One was suffering from multiple sclerosis (31) and another had hypertension (24). Three patients were chronic

[7] Solvent system: Butanol and water (100:15 by volume).

Identities of metabolites 1 and 2 were confirmed. Metabolite 3 appears to be released on glucuronidase treatment of the glucuronide fraction. Metabolite 5 appears to be the glucuronide of metabolite 3, and metabolite 4 the glucuronide of hydroxymeprobamate.

alcoholics, and in two instances the individuals had been drinking heavily prior to ingestion of the drug. The most consistent symptom observed during coma was severe hypotension.

Allen and Black (30) discussed a case in which the patient endured episodes in which blood pressure was not obtainable and the pulse not palpable during a 3-hour period. Depression of respiration was also noted during the circulatory collapse. Loss of reflexes and lack of response to sensory stimuli were present in all the cases outlined. The pupils were usually miotic and did not react to light. In two cases (30, 31) in which only dilation of the pupils was observed, there had been a lapse of several hours between ingestion of the drug and the beginning of treatment. There were respiratory difficulties in some cases due to either pharyngeal relaxation (30) or accumulation of secretions requiring therapeutic measures. In one case (29) apnea developed during attempted gastric lavage. In general, respirations were shallow and somewhat increased. Slow respiration was noted in one instance (31); cyanosis was cited in two (27, 29); while in one case (31) the skin was pale and there was apparent cutaneous vasoconstriction. An elevation of temperature was recorded once (29). In one case (32) bloody material was vomited 17 hours after ingestion.

The few cases (24, 28, 32) in which the time element was more or less established, indicate that the symptoms of poisoning begin shortly after ingestion of the drug, and coma follows quickly, probably within an hour after intake. This may be related to the fact that the full pharmacological effect of the drug in therapeutic doses is known to occur within 15 to 30 minutes after ingestion (35).

In addition to the cases summarized in Table 4, other cases have been reported in which over-doses of meprobamate have produced little or no serious effect. Greenberg and co-workers (36) cite a case in which 22.4 gms. were ingested which merely resulted in drowsiness and vomiting. Dixon (37) reported 3 cases where 15, 25, and 45 tablets caused deep stupor with hyporeflexia, dilatation of the pupils, but no effect on circulation and respiration. Dixon (37) reported a case of Robie in which a woman took 16 tablets and 3 grains of phenobarbital.

TABLE 4

Cases of Meprobamate Intoxication

| Reference | Sex Age | Amount Gms.[8] | Amount Mg./Kg.[9] | Interval[10] | Initial Condition | Recovery from Coma | Remarks |
|---|---|---|---|---|---|---|---|
| Shane & Hirsch (24) | F 39 | 2.4 to 7.2 | 70 | 15-30 min. | Stupor | 8 hrs. after admission | Was taking phenobarbital. Excited and violent within 30 min. Given 25 mg. chlorpromazine. Stomach lavage. |
| Senseman (25) | F — | 4.6 or 9.2 | 100 | — | — | Uneventful | Severe shock and stupor. No details. |
| Shane & Hirsch (24) | F 58 | 6 | 86 | About 1 hr. | Coma | About 2 hrs. after start of treatment | Returned to normal 16 hrs. later. |
| Heberden & Cooper (26) | M 30 | 8 | 46.7 | About 10 hrs. | Coma | Within a minute after i. v. pentylenetetrazol | Stomach lavage. |
| Charet et al. (27) | F 50 | 10 | 140 | About 6 hrs. | Coma | About 3 hrs. after admission | Immediate reappearance of reflexes after pierotoxin. |
| Shane & Hirsch (24) | F 56 | 10 | 140 | 6 hrs. | Coma | About 48–54 hrs. after ingestion | Bronchopneumonia 2 wks. before. Condition worse day after ingestion. |
| Deisher (28) | F 32 | 12 | 170 | 20 min. | As if inebriated | After 10 hrs. of definite stupor | 3-4 qts. beer consumed during 12 hrs. prior to intake. Mildly stuporous 45 min. after ingestion. Stomach lavage. At least 2 tablets and suspended material recovered. |

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Collins-Dineen (29) | F 53 | 14 | 200 | 9 hrs. | Coma | 24 hrs. after admission | Apnea during attempted gastric lavage. Picrotoxin. Some reflexes reappeared 3 hrs. after admission. |
| Allen & Black (30) | F 57 | 12–20 | 230 | 2 hrs. | Coma | 15 hrs. after onset | Stomach lavage. For 3 hrs. repeated episodes respiratory and vasomotor collapse. Electro-stimulation and Levarterenol. |
| Woodward (31) | F 32 | 19.2 | 270 | — | In shock | 6 hrs. | Active in 18 hrs. |
| Woodward (31) | F 42 | 20 | 290 | — | — | After 16 hrs. | Alcoholic. Inebriated 3 days prior to ingestion. No medical attention. She notified doctor 2 hrs. after awakening from coma. |
| Lockhart (32) | F — | 36.8 | 615 | — | — | 40 hrs. after ingestion | Coma in less than 1 hr. At 17 hrs. vomited bloody gastric fluid. Tracheostomy performed. Died from pulmonary edema due to overhydration 77 hrs. after recovery from coma. |
| Hiestand (33) | F 40 | 36–38 | 530 | 1 hr. | Coma | 36 hrs. after admission | Complete recovery after 72 hrs. |
| Woodward (31) | F 30 | 38.4 | 550 | 4 hrs. | Coma | 40 hrs. after admission | Stomach lavage yielded considerable material. |

[8] Quantity available or that stated by the patient.
[9] Estimated for all cases except (26), (28), (32) using an average body weight of 70 kg.
[10] Interval between time of ingestion and beginning of treatment.

She was arousable upon admission 2 hours later and completely recovered after 4 hours without treatment. Perlstein (38) discussed a case involving a 20-year-old girl who ingested 25 tablets (5 to 10 gms.) in an unsuccessful suicide attempt; toxic effects are not noted. Selling (34) reported that a woman who took 20 gms. over a period of 24 hours experienced bradycardia and sleepiness for about 12 hours. He also observed that a man who ingested about 40 gms. within 24 hours experienced no serious effect.

*Therapeutic Measures:* A great variety of therapeutic measures was employed in these cases. In general, treatment was symptomatic and supportive and included the use of analeptics (nikethamide, phenylephrine, epinephrine and ephedrine) stimulants of the central nervous system (caffeine, amphetamine), penicillin and intravenous infusion of saline and glucose. Oxygen was administered in about half of the cases; airway was maintained in 3 instances and tracheostomy was performed once (32). Bitemporal cerebral electrostimulation was found necessary in one case (30) to treat respiratory and circulatory collapse. Stomach lavage was performed in 4 cases, failed in another and abandoned in the sixth when apnea developed. Pentylenetetrazol effected a dramatic recovery in one instance (26) and is recommended as a specific antidote in meprobamate poisoning. It is interesting that mephenesin, the parent compound of meprobamate, is known to antagonize the convulsive effects of pentylenetetrazol. Picrotoxin effected the immediate reappearance of reflexes and apparently shortened the period of coma in one case (27). However, in another case (29), although the same observation in regard to reappearance of reflexes was made, the duration of coma did not seem to have been affected.

**Chlorpromazine (10–(3–dimethylaminopropyl)–2–chlorphenothiazine) Thorazine ®** [1]

*Methods of Determination:*

A simple method which makes use of the ultraviolet absorption of chlorpromazine has been devised in the Smith, Kline and French Laboratories

[1] Smith, Kline and French Laboratories.

(39) for the determination of the drug in plasma. The base is easily extracted into ether from alkaline media. Plasma (10 ml.) and 0. 1N NaOH (1 ml.) are extracted with 20 ml. of ether. The ether phase is separated and the aqueous phase is again extracted with 4 more 20 ml. portions of ether. The combined ether extracts are washed with 1 ml. of 0. 1N NaOH followed by an additional washing with 5 ml. of distilled water in order to remove extraneous substances. The ether is then extracted with 3 ml. of 1N $H_2SO_4$. The acidic solution, centrifuged if necessary, is transferred to a cuvet and the absorbance from 240 to 300 mu is measured. From the maximum value at 255 mu is subtracted the value obtained at 280 mu. The amount of chlorpromazine present is calculated by reference to a standard curve of absorbance versus concentration of pure drug added to 10 ml. of plasma in different amounts (5–50$\gamma$) and treated in the same way.

The amount of total chlorpromazine may be determined by adding 8 ml. of hydrochloric acid to 10 ml. of plasma and heating on a water bath for 5 minutes. After rapid cooling, saturated NaOH solution is added dropwise to make the pH greater than 12. The contents of the tube are cooled after disappearance of precipitate at this stage, and the procedure continued as above. As little as 0.2$\gamma$/ml. plasma may be detected in this way. Mention is made of the instability of chlorpromazine and that the rapidity of the determination after withdrawing of the sample is important.

Dubost and Pascal (40) have outlined a colorimetric procedure for the determination of chlorpromazine in blood and urine. This method makes use of the reaction between sulfuric acid and the drug after its extraction with ether from alkaline solution. Total drug may be determined in the same way following hydrolysis of the blood or urine. They later advised the addition of a reducing agent such as formalin to stabilize the color (41). This method has been most widely used and modified by many workers since its introduction. Berti and Cima (42) used ion exchange resin to extract the base from urine. Brignon (43) shortened the time by treating the serum with an alcohol-acetone mixture and then applying the reaction in hydrochloric acid solution after evaporation of the solvent. Henriksen and co-workers (44) and Gouzon and co-workers (45), analyzing tissue of animals, first treated the tissue with potassium hydroxide solution. Citterio and Mattei (46) added nitric acid in the final step for higher sensitivity when analyzing blood and urine. In their study of tissue of mice receiving the drug, Berti and Cima (47) also used colorimetry. They used nitrous acid to oxidize extracts of the tissue. Forrest and Forrest (48) have detected the drug in the urine of problem patients when the supervision of chlorpromazine intake was difficult. By the addition of sulfuric acid and ferric chloride to as little as 1 ml. of urine, a daily dose of 25 mg. is easily detected and the intensity of the color makes possible an estimation of the intake and of the time taken. Small quantities have been detected in the urine one week after a single dose. Cavanaugh and Ervin (49) have outlined a similar procedure for testing body fluids but use only phosphoric acid. They recommend the addition of ferric chloride when the color is weak and there may be confusion with color due to natural chromo-

gens. The test may also be applied directly to serum and spinal fluid, but the authors state that the latter has not yielded positive results.

With these methods there is a lack of specificity. Salzman and Brodie (50) have developed a specific method for determining the drug in plasma, urine and tissue. The method is not sensitive enough for the determination of the drug in plasma of humans receiving therapeutic doses because of the low levels. In this method a mixture of heptane and isoamyl alcohol is used to extract the drug from alkaline medium. The major metabolite, chlorpromazine sulfoxide, may be removed by washing the solvent with appropriate buffer. The chlorpromazine is then extracted into hydrochloric acid solution and quantitation is accomplished by spectrophotometry.

Chlorpromazine sulfoxide has been isolated from the urines of dogs and successfully characterized (50) (51). The presence of two other metabolites has been established by means of paper chromatography. Berti and Cima (42, 52) have made an extensive investigation of the transformation and elimination of chlorpromazine by many different animal species receiving the drug by various routes and by man receiving the drug orally in a single dose. Their results with dog and man are in accord with those of Salzman and co-workers (50, 51). These workers report that negligible amounts of unchanged drug are excreted by man and that about 5% of the chlorpromazine is eliminated as the sulfoxide, while dogs excrete about 1% of the parent drug and about 12% as the sulfoxide.

Berti and Cima (52) found that the three metabolites are present in the urines of all the animals studied and believe from hydrolysis studies that one of the minor metabolites represents a glucuronic acid conjugate of chlorpromazine (42). They also observed that there is a larger amount of unchanged drug in the urine when the animal is more sensitive to the central depressant action of the drug (52). They report that in man, the sulfoxide represents more than 90% of the total metabolites recovered in urine; Davidson and co-workers in a recent report (53) regarding the action and metabolism of this interesting metabolite conclude that although the compound is a relatively weak and short-acting sedative agent in man, it does not contribute significantly to the action of the parent drug. The sulfoxide itself is extensively metabolized yielding a substance identified by means of paper chromatography as being similar to one of the minor metabolites after chlorpromazine injection (50).

In agreement with Gouzon and co-workers (45), Salzman and Brodie (50) using dogs reported that the drug localized itself in various body tissues, being highest in the brain. Berti and Cima (47) reported that after subcutaneous injection the concentration of chlorpromazine rises more slowly in the kidney of mice but reaches higher values than the other organs. They found elevated concentrations in the brain. Wase and co-workers (54, 55) using mice and rats receiving $S^{35}$–chlorpromazine report that the drug accumulates in the brain, especially the hypothalamus. Concentrations are also reported as being high in the lungs of dog (50) and other animal species (47, 55, 56).

Salzman and Brodie (50) reported that when the drug (20 mg./kg.) is injected intravenously in dogs, the drug level in plasma reached an average

of about 0.2 mg. % thirty minutes later. The level drops to about 0.1 mg. % after one hour and is about the same at the end of three hours. This is in agreement with the blood studies conducted by Dubost and Pascal (40) using dogs receiving daily subcutaneous doses (20 mg./kg.) for 3 weeks. Three hours after the 18th injection, the blood contained 0.6 mg. % of chlorpromazine. On the 19th day of treatment, the blood contained 0.3 mg. % two hours after injection. Henriksen and co-workers (44) reported a blood level of 0.3 mg. % 15 minutes after intravenous injection of chlorpromazine to rats (25 mg./kg.); 30 minutes later, the level was about the same, 0.2 mg. %. They found, after subcutaneous injection (25 mg./kg.), that small amounts of detectable substance remain in the blood and are found there over a long period of time corresponding to the long-lasting resorption of the drug; the level remains at about 0.1 mg. % for 12 hours and drops to almost half of this value after 48 hours. The excretion in the urine lasted more than 3 days after one subcutaneous injection and more than 8 days after an 8 days' treatment. After oral administration, it starts more rapidly, but lasts just as long as after parenteral administration.

*Toxicity:*

Chlorpromazine has had a most diversified and varied career since its synthesis in France in 1950 in the Rhone-Poulenc Laboratories. This compound was the first of the synthetic ataraxic agents, and it has been used in practically every field of medicine. Reported instances of misuse, either accidental or deliberate, of this powerful autonomic nervous system depressant have been rare when one considers the great amount of literature devoted to its study.

Twenty-four cases of intoxication due to overdose of chlorpromazine, taken either accidentally or intentionally, have been reported in literature (57–75) and are summarized in Table 5. Complete details are not available for all cases. The ingested amounts ranged from 250 to 9800 mg. (7–140 mg./kg.) presumably taken as a single dose, but it was so stated in only three instances.

It is evident that ingestion of about 10 to 50 mg./kg. resulted in deep sleep, stupor and coma. When an amount over 64 mg./kg. was ingested, tremor and convulsions were also noted in most instances. This is in accordance with the observations of Salzman and co-workers (51) on dogs and Essig and Carter (76) on monkeys, regarding the effect of chlorpromazine on the central nervous system. Differences in the clinical picture of intoxication following large overdosages are explained either by the partial removal of the ingested material by gastric lavage or by the possibility that the

TABLE 5

Cases of Chlorpromazine Intoxication

| Reference | Sex Age | Amount Mgs.[12] | Amount Mg./kg.[13] | Outcome | Remarks |
|---|---|---|---|---|---|
| Fontan et al. (57) | — 3 | 250 | 17 | Recovery | Vigil coma, hypothermia, respiratory collapse. |
| Henne & Henne (58) | — | 500 | 7 | Recovery | Coma, areflexia. |
| Beal (59) | F 21 mos | 625 | 52 | Recovery about 48 hrs. after ingestion | Coma, muscular hypotonia, areflexia, shock. Stomach lavage with recovery of considerable amount of drug. |
| Tofte (60) | F 38 | 625 | 9 | Recovery | Schizophrenic. Hypotension, congestion of skin, drowsiness for a few days. |
| Haggerty (61) | M 13 mos | 750 | 75 | Death on 4th day | Stomach lavage within hr. with no recovery of tablets. Coma within 6 hrs. Fever and convulsions in 12 hrs. |
| Sinha & Mitra (62) | F 27 | 750 | 11 | Recovery about 12 hrs. after ingestion | Psychotic. Found in coma 5½ hrs. after intake. Stomach lavage. Myosis, hypothermia, tachycardia, cyanosis, areflexia. |
| Winkelman (63) | — | 750 | 11 | Recovery in a few days | Coma. No analeptics given. |
| Langeron et al. (64) | — — | 1000 | 14.5 | Recovery | "Moderate intoxication." |
| Aubertin et al. (65) | F 39 | 1000 | 14 | Recovery about 24 hrs. after ingestion | Also took a few 100-mg. tablets phenobarbital. Coma in ½ hr. Areflexia, hypothermia, tachycardia. Stomach lavage about 1½ hrs. after ingestion. |

| | | | | | |
|---|---|---|---|---|---|
| Graux et al. (66) | F 73 | 1000 | 14 | Recovery in about 12 hrs. | Vigil coma. Hypothermia, hypotension. |
| Haarstad (67) | F 39 | 1200 | 21 | Recovery in about 16 hrs. | Drowsiness, slurred speech, stupor several hrs. hypotension, hypothermia, myosis. |
| Henne & Henne (58) | F 51 | 1200 | 17 | Complete recovery after 3 days | Chronic alcoholic. Stomach lavage 20 min. after intake with recovery of tablets. Hypotension, tachycardia, hypothermia. At 3 hrs: motor agitation, hemiparalysis of epiglottis, difficulty in swallowing. At 5 hrs: agitation, light coma for 2 hrs. changing to deep sleep for about 12 hrs. Speech and deglutition difficulty persisted after coma. |
| Henne & Henne (58) | — — | 1250 | 18 | Recovery | Coma, hypotension. Stomach lavage. |
| Tofte (60) | — — | 1250 | 18 | Recovery | Unconsciousness. |
| Vallat and Lepetit (68) | F — | 1300 | 22.4 | Rapid recovery | Deep coma for 5 hrs., hypotension, areflexia, severe stomatitis. |
| Henne & Henne (58) | — — | 1750 | 25 | Recovery | Coma, hypothermia. |
| Hopkin (69) | — — | 1750 | 25 | Recovery in 3 days | No details cited. |
| Rainaut (70) | M 49 | 2500 | 36 | Recovery in less than 24 hrs. | Alcoholic. Muscular hypotonia, areflexia, bilateral Babinski, tachycardia, tachypnea, sweating. |

[12] Quantity available or that stated by the patient.

[13] Estimated value for all cases except for (64) (67) (68). An average weight of 70 kg. was used for adults and average weight corresponding to age for the children.

TABLE 5

(Continued)

Cases of Chlorpromazine Intoxication

| Reference | Sex Age | Amount Mgs.[12] | Amount Mg./kg.[13] | Outcome | Remarks |
|---|---|---|---|---|---|
| Ferguson (71) | F 32 | 4500 | 64 | Recovery about 16 hrs. after ingestion | Found in coma about 12 hrs. after intake. Respiratory distress, cyanosis, tremor-like movements of hands, convulsion after i. v. Ritalin ®, bradypnea. |
| Dotevall (72) | M 25 | 5000 | 71 | Recovery about 18 hrs. after ingestion | Found in deep sleep about 12 hrs. after ingestion. Myosis, hypothermia. |
| Dotevall (72) | F 51 | 5000 | 71 | Recovery about 18 hrs. after ingestion | Had been in mental hospital. Found somnolent 4 hrs. after intake. Disorientation, hypotension, hypothermia. Stomach lavage with no recovery of drug. |
| Spratt & Dean (73) | F 40 | 5000 | 71 | Recovery about 20 hrs. after ingestion | Psychotic. Found unconscious about 6 hrs. after intake. Hypotension, flaccid paralysis, areflexia, myosis, slurred speech, twitching of face and neck, convulsion; given Dilantin; semicomatose at least 7 hrs. |
| Samuels (74) | F 18 | 5000 to 10000 | 71 to 142 | Recovery in about 40 hrs. | Stomach lavage. Somnolent at 1½ hrs., semicomatose at 6 hrs., coma at 12 hrs., semicomatose at 21½ hrs. Responding to stimuli at 26 hrs. Areflexia, myosis, convulsions at 15 and 16 hrs. Tachycardia, tachypnea, fever, bilateral Babinski, tremor. |
| Douglas & Bates (75) | F 52 | 9800 | 140 | Recovered 6 hrs after ingestion | Within 1 hr. drowsy, confused, ataxic, and in shock. Stomach lavage with recovery of 1675 mg. Respiratory collapse at 4 hrs. Picrotoxin and amphetamine. Necrotic patches on fauces. |

[12] Quantity available or that stated by the patient.

[13] Estimated value for all cases except for (64) (67) (68). An average weight of 70 kg. was used for adults and average weight corresponding to age for the children.

amount actually was less than the alleged intake. The same reasons may account for the lack of coma and for the relatively short duration of the state of intoxication in spite of massive dosage such as seen in the case of Douglas and Bates (75).

Ingestion of 75 mg./kg. of the drug by a 13-months-old child resulted in death (61). This case is the only published fatality attributed to intoxication by chlorpromazine. Death occurred during hospitalization on the fourth day after ingestion. Autopsy showed generalized cerebral edema. The blood contained 0.1 mg. % of free chlorpromazine.[14]

We had an opportunity to study another case of fatal poisoning due to this drug taken by a 40-year-old woman about 100 kg. in weight, who was found dead 3 days after her disappearance. She had been a mental patient who had previously attempted suicide, once by barbiturates and another time by cutting her wrists. Before her disappearance she allegedly had threatened to kill herself with Doriden® and Thorazine®. A bottle of Thorazine was found near her body. At autopsy there was moderate pulmonary congestion and edema, focal intra-alveolar hemorrhage and congestion of the viscera. Slight pulmonary emphysema, coronary atherosclerosis and adenomyosis of myometrium were also found. The blood contained 0.3 mg. % of drug.[15] No alcohol or barbiturates were present in the blood. No Doriden was found in the urine. The available amount of chlorpromazine is unknown. In an attempt to estimate the amount ingested, we arbitrarily used the blood levels observed in animals receiving the drug intravenously (50). A rough estimate indicated that at least 2000 mg. could have been ingested to reach the observed level of chlorpromazine in the blood of the deceased.

In sequence of frequency and number of cases, the various symptoms reported in cases appearing in the literature are as follows: coma, stupor or deep somnolence, 19; hypotension, 11; hypothermia, 10; suppression of reflexes, 8; tachycardia, 6; myosis, 4; tachypnea, 4; convulsions, 4; tremor or muscular twitchings, 4; muscular hypotonia, 3; respiratory collapse, 3; slurred speech, 3; cyanosis, 2; elevation of temperature, 2; positive Babinski, 2; stomatitis and pharyngitis, 2; agitation, 1; ataxia, 1; hemiparesis of epiglottis, 1; difficulty in swallowing, 1; heavy sweating, 1; bradypnea, 1. It is apparent that somnolence, stupor or coma were by far the most common and

[14] Analysis by Frank Stratton. Method of Heming and Flanagan (39).
[15] Method of Heming and Flanagan (39).

prominent manifestations of intoxication. In the cases in which the time element was established the patients had lapsed into stupor or coma within 30 minutes to 6 hours after ingestion. The coma lasted from 1½ to 48 hours.

Next to stupor and coma, the most commonly observed toxic manifestations were hypotension, hypothermia and abolition of reflexes. Reports of detection and quantitation of chlorpromazine are scant in the reported cases. Douglas and Bates (75) report that cerebrospinal fluid examined 5 days after ingestion showed a "just detectable positive reaction." Tofte (60) found traces of chlorpromazine in the blood the day after ingestion and none later. He also reported that the amount of the drug excreted in the urine over a period of 14 days was 66 mg. representing approximately 10% of the ingested dose; the consecutive daily excretion was 40; 5.1; 7.3; 5.0; 4.2; 1.85; 0.63; 0.84; 0.50; 0.26; 0.25; 0.29; and 0.08 mg. The method of determination was not given.

Evidence of liver damage was not noticed in the reported cases. Samuels (74) observed an increase of the serum alkaline phosphatase which, he stated, may indicate a transient liver damage.

The treatment applied in the cases studied was largely symptomatic and supportive. Stomach lavage was performed in 9 cases. Douglas and Bates (75) and Beal (59) emphasize that gastric lavage is indicated even after a considerable lapse of time following ingestion since chlorpromazine diminishes the gastric motility thus allowing the removal of some of the ingested material still remaining in the stomach.

The use of central nervous system stimulants such as caffeine, amphetamine, strychnine and picrotoxin is not yet resolved in combating coma. It is interesting to note that in the cases of intoxication discussed here, several of these agents have been used with no striking comments regarding their adverse effect. However, some authors advise against the use of these substances since chlorpromazine itself in large doses provokes stimulation of the central nervous system (51, 61, 75, 76). When convulsions occur, the choice of an anticonvulsive drug is difficult since chlorpromazine may potentiate the action of many central nervous system depressants such as barbiturates and narcotics as well as anesthetics and alcohol

(77). Haggerty (61) considers paraldehyde and ether to be the safest in such instances. Methyl-phenidylacetate (Ritalin ®) is mentioned as a drug of choice in fighting coma (71). The makers of the drug are quite emphatic in their recommendations regarding the use of vasopressor drugs to combat hypotension. They state that nor-epinephrine is the most suitable and that epinephrine should not be used since the chlorpromazine may reverse its action (77).

Haggerty (61) suggests that exchange transfusion may be beneficial in treating intoxication in children and that hemodialysis would be of no value.

**Summary**

The literature devoted to the toxicology of glutethimide, meprobamate and chlorpromazine has been reviewed. Cases reported in the literature and additional cases studied pathologically and toxicologically by us involving over-ingestion of these drugs have been summarized and discussed.

Quantitative determination of these drugs in biological media and their differentiation from metabolic products are possible by means of colorimetry, ultraviolet spectrophotometry and paper chromatography. Most of the methods have recently been published, and some have not yet appeared in the literature.

Levels in biological material following intoxication are given. Since these are few in number, correlation between dosage, concentration and physiological effects cannot yet be established.

We hope that this paper will stimulate further investigation of these drugs. An accumulation of information will aid in the proper handling of emergency cases and be useful to the medicolegal investigator in his evaluation of cases in which these drugs have been involved.

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Department of Legal Medicine
Harvard University Medical School
25 Shattuck Street
Boston 15, Mass.

# A Simple Method for Detecting and Estimating Ethylene Glycol in Body Materials; Analytical Results in Six Fatal Cases*

*R. N. Harger, Ph.D., and R. B. Forney, Ph.D.,** Indianapolis, Indiana*

## Introduction

While many fatal, human cases of ethylene glycol poisoning have been reported and the resulting tissue pathology has been described for some of them, (1), we have been unable to find any published figures for the concentrations of glycol in the tissues and fluids of the victims of such poisoning.

Determinations of the distribution and excretion of ethylene glycol with animals, sacrificed after receiving this glycol, have been reported by Hanzlik et al. (2), and by Fabre and Rousseau (3). For determining the glycol, these investigators employed the periodic acid reaction of Malaprade (4), in which ethylene glycol is oxidized to formaldehyde:

$$C_2H_4(OH)_2 + HIO_4 \longrightarrow 2\,HCHO + HIO_3$$

An excess of M/10 periodic acid is used and the portion remaining is determined by adding an excess of N/10 arsenious acid and then back-titrating with N/10 iodine solution. This titration figure, subtracted from the blank titration result,

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** Division of Toxicology, Indiana University School of Medicine, Indianapolis, Indiana.

gives the periodic acid used to oxidize the glycol. One ml. of N/10 iodine is equivalent to 3.1 mg. of ethylene glycol.

As shown by the above equation, each atom of periodate oxygen used yields two molecules of formaldehyde. While many other aliphatic compounds having 1, 2 OH groups, and perhaps other OH groups, give formaldehyde when treated with periodic acid, none of them yields more than one molecule of formaldehyde per atom of oxygen used, and some yield much less than this. Ethanolamines do yield two molecules of formaldehyde per atom of oxygen, but ammonia is also formed (5).

During our analyses of body materials from two victims of fatal ethylene glycol poisoning in 1943, it occurred to us that a determination of the formaldehyde formed by periodic acid oxidation, checked against the periodate used, would show whether the substance reacting with the periodate was all ethylene glycol. For determining formaldehyde we used the color produced by the Wright-Elvove modified Schiff reagent (6, 7). We found that the theoretical amount of formaldehyde was formed, namely, two molecules for each atom of iodate oxygen used. We have not previously reported this double analysis procedure.

In 1945, Desnuelle and Naudet (8) published a method of analyzing for glycerol, ethylene glycol, and propylene glycol in a mixture of the three by determining the quantities of formaldehyde, acetaldehyde and formic acid produced on treatment with periodic acid. Formaldehyde was estimated from the red color produced upon adding phenylhydrazine and potassium ferricyanide. Bricker and Lee, in 1952 (9), described a method for determining ethylene glycol in procaine penicillin, which involves periodate oxidation followed by colorimetric determination of the resulting formaldehyde, on heating the latter with chromotropic acid. Periodic and iodic acids interfere, and must be precipitated with lead acetate prior to adding the chromotropic acid.

In employing the Wright-Elvove modified Schiff reagent for determining formaldehyde, we found that the presence of periodic acid intensifies the resulting color about six-fold, with no color production if formaldehyde is absent. Thus, in our method, removal of $HIO_4$ and $HIO_3$ is unnecessary and

undesirable. The depth of color produced deviates somewhat from Beer's Law in that an increase in the amount of glycol causes a proportionately greater increase of color.

**Description of Method**

A. *Reagents.*

1. *Sulfuric acid, 2/3 N.* Dissolve 20 ml. of C.P. sulfuric acid in 1 liter of distilled water. Titrate with standard base, and add more acid, or water, as needed.
2. *Sodium tungstate, 10%.*
3. *Periodic acid, M/10.* Dissolve 2.13 g. of $NaIO_4$[1] in 100 ml. of N/3 sulfuric acid.
4. *Modified Schiff reagent.* Weigh out 0.2 g. of a good grade of basic fuchsine [2] and transfer to a 200 ml. flask. Add 120 ml. of water heated almost to boiling. Shake well until complete solution occurs and cool to room temperature with running water. Dissolve 2 g. of sodium bisulfite (meta) in 20 ml. of water and mix this with the cooled fuchsine solution. Next, add 2 ml. of conc. hydrochloric acid and 60 ml. of water. Mix well and place in a glass-stoppered bottle. The solution should become practically clear in a few minutes. If kept in a refrigerator it will function properly for 2 or 3 weeks. If too much $SO_2$ gas escapes from it, a brown color will result on adding it to the oxidized glycol and excess $HIO_4$.

B. *Procedure for Blood.* Take 1 ml. of the blood with 7 ml. of water and add 1 ml. of the tungstate solution. With vigorous shaking add, dropwise, 1 ml. of the sulfuric acid solution. Stopper the flask and shake well. Filter through a small dry filter paper. Unless these directions are followed the filtrate may contain a little protein, which will cause the result to be too high.

Place in a small test tube 1 ml. of the protein-free filtrate and then 4 ml. of water. Next add 0.25 ml. of the M/10 $HIO_4$ solution and shake. Allow to stand 10 minutes. Quickly introduce 2 ml. of the Schiff reagent and mix. After 25 minutes read the depth of color with a photoelectric colorimeter set

[1] G. Frederick Smith Chemical Co., Columbus, Ohio.
[2] Coleman & Bell #B-300 has been found satisfactory.

at wavelength 555 mμ. Compare the result with the optical density curve for 10 to 70 λ of ethylene glycol dissolved in water and run in the same way. With quantities above 30 λ the final solution must be diluted to 2- to 3-fold. If the color is still too strong, repeat the analysis with less of the protein-free filtrate. Run a blank with distilled water. To check whether the color of the unknown is all due to ethylene glycol, analyze another portion of the blood by the method of Lehman and Newman (10).

C. *Procedure for Urine.* Diluted urine may be analyzed directly, using the procedure for the protein-free filtrate of blood.

D. *Tissues.* Weigh out 50 g. of the tissue and add 200 ml. of water. Make a uniform suspension of tissue and water by means of a Waring blendor. Measure out 25 ml. of the suspension. Add 15 ml. of water, 5 ml. of the tungstate solution, and, with shaking, 5 ml. of the ⅔ N sulfuric acid. Filter. The filtrate should be clear and free from protein. Continue the analysis as with the protein-free filtrate of blood.

E. *Result with Glucose.* One mg. (1000λ) of glucose was dissolved in 5 ml. of water and analyzed by the colorimetric method, as with the diluted protein-free filtrate. No color was developed. Therefore, diabetes will not cause a false positive result.

**Results by the Colorimetric Method with Bloods from Hospital Patients**

Samples of tungstic acid protein-free filtrate of bloods from hospital patients, made for routine analyses in our clinical laboratory, were analyzed by the colorimetric method given in the previous section. These patients represented all ages, and a great variety of disorders. All available samples for a period of about two months were used. In this survey we tested a total of 966 samples of blood from 532 patients. All samples gave a trace of color and a few yielded a moderate color. The distribution of results, with the optical density expressed as ethylene glycol, follows:

| Blood samples | % of total | O.D., as ethylene glycol Mgs. % |
|---|---|---|
| 744 | 77 | 1 to 7 |
| 196 | 20 | 8 to 16 |
| 20 | 2 | 17 to 25 |
| 5 (2 patients) | 0.5 | 28 to 35 |

We are studying the case histories and medication of the two patients whose blood consistently gave the highest readings obtained in our series.

It should be pointed out that the highest reading obtained, a color equal to that given by 35 mg. % of ethylene glycol, is equivalent to only about one-tenth of the level of ethylene glycol found in the blood of our four ethylene glycol victims where the fatal period was a few hours.

Fabre and Rousseau (3), using the method of titrating the excess of periodic acid, reported that normal rabbit bloods yielded a blank equivalent to 5–7 mg. % of ethylene glycol. The urine blank was equivalent to 85–98 mg. % of ethylene glycol, and the blank of various tissues ranged from 12 to 60 mg. %, expressed as ethylene glycol.

**Analytical Results with Six Fatal, Human Cases of Ethylene Glycol Poisoning**

We have had an opportunity to do toxicological analyses on materials from the bodies of six people who died of ethylene glycol poisoning. The cases occurred in pairs, each pair consuming ethylene glycol from the same source. The results of our analyses for ethylene glycol, and some other pertinent data, are given in Table I.

The glycol figures for cases 1 to 4, inclusive, were obtained with the colorimetric procedure set forth under "Description of Method," and these results were checked by analyses of the same samples with the periodate titration method of Lehman and Newman (10). There was good agreement between the two methods. With cases 5 and 6, we used only the colorimetric determination of the formaldehyde produced following oxidation with periodic acid.

Cases 1 and 2 each ingested an orange-colored fluid which they obtained from a junk dealer, who called it "Apricot

TABLE I

Ethylene Glycol Present in Body Materials in Six Fatal Cases of Ethylene Glycol Poisoning

| Case # | Date | Subject | Fatal Period | Body Material | Glycol Mgs. # |
|---|---|---|---|---|---|
| 1. | 9–28–43 | K. H. | 6 Hrs. | Blood | 423 |
| | | | | Stomach & contents | 569 |
| | | | | Liver | 812 |
| 2. | " | R. N. | 2 Days | Blood | Trace |
| | | | | Stomach | " |
| | | | | Liver | " |
| 3. | 3–28–57 | E. H. | Found dead | Blood | 384 |
| | | | | Urine | 1080 |
| | | | | Stomach contents | 616 |
| | | | | Liver | 704 |
| | | | | Kidney | 583 |
| | | | | Brain | 390 |
| 4. | " | V. H. | 36 Hrs. | Blood | 24 |
| 5. | 4–21–57 | D. S. | 8½ Hrs. | Stomach | 412 |
| | | | | Tissue composite | 244 |
| 6. | " | J. S. | 2 Hrs. | Stomach contents | 311 |

Brandy." Analyses showed that it contained 32 per cent ethylene glycol dissolved in water, and about 0.15 per cent of iron rust. Case 1 died within 6 hours after ingesting the fluid, while case 2 lived about 2 days after he drank the "beverage." This accounts for the great difference in the glycol levels of the two victims. The blood of case 1 contained 3.5 mg. % of creatinine and 2.6 mg. % of uric acid. With case 2 the blood creatinine was 6.2 mg. % and the uric acid was 6.0 mg. %, showing that considerable kidney damage had occurred in his case. His kidneys contained the typical oxalate crystals often described in fatal cases of ethylene glycol poisoning. No such crystals were found in the kidneys of case 1.

Cases 3 and 4 were man and wife who consumed a fluid they called "Apple Cider." It was also antifreeze fluid from an automobile radiator, because it contained 30 per cent ethylene glycol, water, and a small amount of brownish-yellow iron rust. When the rust settled the fluid had a light blue

color of the dye now added to antifreeze fluids. Case 3 was found dead, having been seen alive a few hours previously, while case 4 lived about 36 hours after she consumed the liquid.

We were unable to learn the source of the ethylene glycol in cases 5 and 6. They were small children who were first thought to be suffering from food poisoning.

In all six cases a general analysis for poisons was conducted, but no other poison was revealed. No ethanol was present.

### Post-Mortem Disappearance of Ethylene Glycol from Blood and Tissues.

With case 3, the analyses of blood, liver, and kidney were repeated after these materials had remained in the refrigerator for 12 days. The blood glycol had dropped from 384 mg. % to 70 mg. %, and the liver and kidney glycol, originally 704 and 583 mg. %, respectively, had decreased almost to zero. These results were checked both by the colorimetric formaldehyde method and also by titrating the excess periodic acid in the method of Lehman and Newman (10). This disappearance of ethylene glycol is being further investigated.

### Summary

A simple colorimetric method for determining ethylene glycol in blood and tissues is described. The tungstic acid protein-free filtrate is treated with periodic acid and the resulting formaldehyde is determined colorimetrically after adding a modified Schiff reagent. Ethylene glycol levels in blood and tissues are reported for six fatal cases of ethylene glycol poisoning in humans.

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Indiana University
School of Medicine
1040 West Michigan Street
Indianapolis 7, Indiana

# Procedure for the Rapid Isolation of Basic Drugs from Tissue and Their Subsequent Purification and Identification*

*Leo R. Goldbaum, Ph.D., and Melvin A. Williams,** Washington, D. C.*

One of the most difficult analytical problems that confronts the toxicologists is the determination of the presence or absence of alkaloids and related basic drugs. Even after the ingestion of lethal doses of these drugs, there are relatively low concentrations present in the tissues. The Stas-Otto procedure (1) generally used for the isolation of these compounds involves many steps, is time consuming and results in a loss of considerable fraction of the drugs. The final extract in this procedure also contains relatively large amounts of interfering normal tissue extractives. These impurities markedly interfere with the chemical and physical tests used for the identification of these drugs.

The following procedure for the detection of basic drugs combines a simple direct extraction of the tissues, with a rapid purification procedure using paper ionophoresis then a subsequent identification of microgram quantities of these compounds. A small sample of tissue is needed since the basic drug is isolated in a relatively pure state making possible

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** Forensic and Aviation Pathology Section, Armed Forces Institute of Pathology, Washington, D. C.

the application of sensitive test to determine the presence or absence of microgram quantities of these drugs. Morphine and related amphoteric drugs are not isolated by the extraction procedure. Another sample and different extraction procedure is used for the isolation of these drugs.

**Choice of Sample**

The kind and size of the sample of tissue or body fluids is an important consideration for determining the presence or absence of basic drugs. When the drug is taken orally, the liver will have the highest concentration in almost all instances. After injection by subcutaneous, intramuscular or intravenous route, the liver may not contain the highest concentration. Other organs, such as lungs, kidney and brain, that have good blood supplies may contain higher concentrations. Urine will always contain a relatively large amount of drug even though only a small percent of the ingested drug is excreted. Bile may contain a large amount of biotransformed drug. This is especially true after morphine and related drugs are taken.

The size of sample used in the following procedure is 50 gms. This sample would make possible the isolation of enough drug to apply sensitive tests to detect the presence or absence of basic drugs even in many instances after therapeutic doses. A repeat analysis, using larger samples, can be made if more drug is needed for conclusive identification.

**Extraction Procedure**

A direct extraction of tissue with a solvent, instead of the usual alcohol procedure, was found to be simpler, more rapid and result in a better extraction of basic drugs from the tissue. The addition of strong base is necessary in order to release many basic drugs that appear to be bound to some constituent of tissue. The solvent found most effective in extracting basic drugs from tissue was ethyl ether. Extraction of the tissue with chloroform resulted in poor recoveries of many basic drugs.

*Procedure.* Fifty grams of tissue (liver) are homogenized with an equal volume of water in a Waring blender, then quantitively transferred to a liter

separatory funnel by washing the blender with small portions of water. Saturated NaOH (10 ml.) are added to the homogenate making the suspension strongly basic. Four hundred ml. of C.P. ether are added and the separatory funnel shaken for a few minutes. The layers are allowed to separate, the ether decanted through a Whatman 41 filter paper into a 500 ml. graduate, collecting a clear aliquot (300 ml.). The ether extract is transferred to a 500 ml. separatory funnel containing 75 ml. of O.5N sulfuric acid and shaken for a few minutes. The basic compounds are removed from the ether layer and enter the water phase as the sulfate. The clear and acid layer is run off into a 250 ml. separatory funnel, made basic with strong sodium hydroxide and shaken with 200 ml. of ether. The water layer is discarded and the ether evaporated in a 100 ml. beaker on a steam bath to approximately 5 ml. then transferred to a test tube (25 ml.), washing the beaker with small portions of ether. One drop of glacial acetic acid is added and the ether evaporated by holding the tube under the hot water tap and gently shaking to prevent bumping. After the ether is volatilized, a few tenths of a ml. of water remain in the test tube.

## Purification of Extract

The purification of the ether extract can be carried out using the technique of paper chromatography (2) or paper ionophoresis. These procedures have many advantages. They can separate a suspected component from many normal extractives and in many instances from other drugs. The use of sensitive spotting agents makes for increased sensitivity in detecting or ruling out of basic drug. A semi-quantitative estimation of concentration may be made by comparison of the spots with known standards. The compounds may be recovered in relatively pure state by proper elution and subsequent extraction by immiscible solvent. Paper ionophoresis technique has the advantage of being more rapid and more sensitive than paper chromatography.

*Apparatus and Technique.* A description of the various commercially available paper ionophoresis or electrophoresis apparatus can be found in the texts of Block & Durrum (3). The apparatus used in this study was the Durrum type. In this apparatus (Fig. 1) the migration chamber consists of a lucite box with a center partition dividing the box into anode and cathode compartments. Platinum foil electrodes dip into the electrolyte solution in the anode and cathode side. The electrolyte for basic drugs ionophoresis is 1N acetic acid. The two compartments are connected by a piece of Tygon tubing to permit initial equilibrium of the liquid level of anolyte and catholyte in order to prevent electrolyte flow currents due to siphoning. During the operation, this tubing is clamped shut. Filter paper strips are supported by a glass support frame with their ends dipping into the elec-

trolyte compartments. The filter paper most satisfactory for ionophoresis is Whatman 3 mm. The peaked roof of the cover permits any electrolyte condensing on the cover to drain back into the electrolyte compartment without dripping upon the filter paper. To supply the potential across the filter paper strips, a power supply unit is needed to vary the output from 0 to 600 volts.

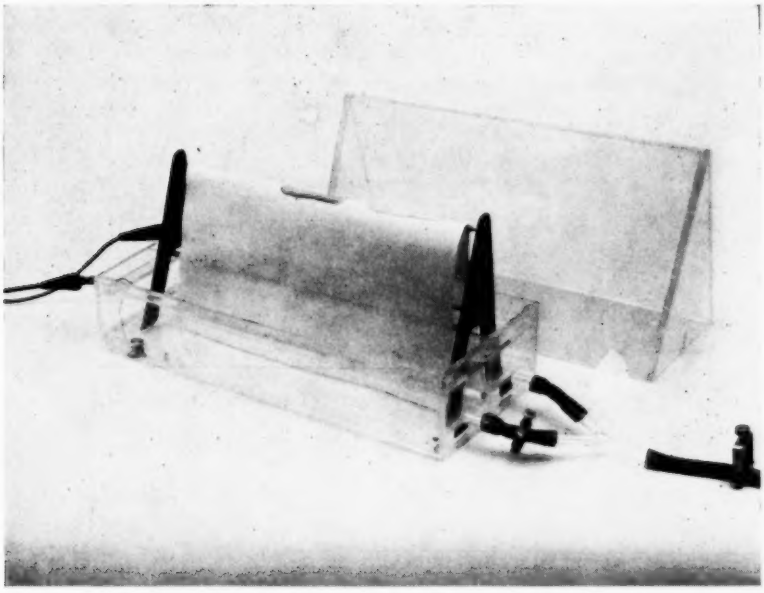

Fig. 1—The migratory chamber of the Durrum ionophoresis apparatus showing filter paper streaked with urine extracts suspended on the rack before the application of the voltage.

*Procedure.* To the residue in the test tube from the extraction procedure, one ml. of absolute ethyl alcohol is added. An aliquot is transferred to the apex of the filter paper strips by streaking across approximately 10 cm. of a Whatman 3 mm. filter paper, 13 inches long and 11 inches wide (Fig. 1). Evaporation is aided by using a hot air blower. The piling up of too much residue should be avoided. This causes improper wetting by the electrolyte, resulting in erratic movements of the components. When the residue is excessive, a larger area of the paper should be streaked. The filter paper strip is suspended on a glass support frame in a migratory chamber. The electrolyte is brought up carefully on either side of the apex with the aid of a medicine dropper or pipette in such a manner that the ascending buffer fronts coalesce at the apex completely wetting the paper. The chamber is covered with 600 volts applied across the paper strips. After one hour, the paper is removed and dried. A semiquantitative estimation

of a basic drug can be made by evaporating known amounts of standard next to the unknown on the paper strip.

*Spotting Agents.* The dried paper strip is first examined in the dark with the ultraviolet light (wave length 255 mu).[1] Those basic drugs that are strongly fluorescent, such as quinine, quinacrine and others, are readily located in concentrations of less than one microgram. The fluorescence of these drugs is different from those of the normal tissue extractives. Compounds that strongly absorb ultraviolet light will be seen as dark areas on the paper. Strychnine and many antihistaminic drugs can be

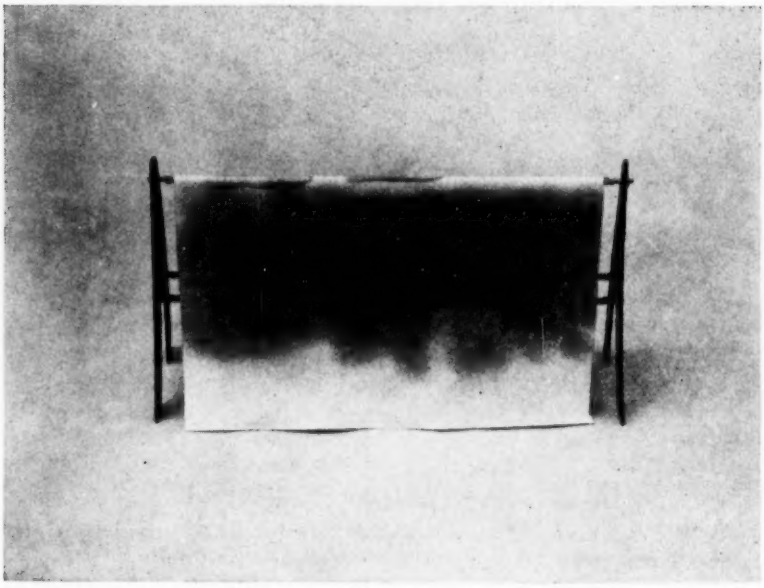

Fig. 2—The dried filter paper sprayed with iodoplatinic acid. The presence of basic drug is shown as dark bands in one of the urine extract and in the standard. The fast moving grey areas of normal basic extractives are seen further down the paper.

located on the paper when present in concentrations of less than 10 micrograms. After marking the areas of fluorescence or absorption, the paper is sprayed with iodoplatinic acid.[2] This reagent reacts with basic compounds

[1] Mineralight. A source of short-wave ultraviolet light; Model SL 2537, Ultra-violet Products, Inc., Pasadena, Calif.

[2] Iodoplatinic Acid Reagent. Mix 45 ml. of 10% potassium iodide, 5 ml. of 5% platinum chloride in 1N hydrochloric acid and 100 ml. of distilled water.

to form blue or black areas. As little as 10 micrograms of most basic drugs can be detected with this reagent (Figs. 2 and 3).

Fig. 3—Iodoplatinate spots of different microgram samples of pyribenzamine for semiquantitative estimation of an unknown. The applied voltage was 6005. and the time was ½ hr.

The group of compounds related to epinephrine, such as ephedrine, amphetamine, methamphetamine and others, require higher concentrations to be detected by iodoplatinic acid. For their detection, the reagent dinitrofluorobenzene is used. After first spraying the paper with iodoplatinic acid, any dark areas that appear are cut out and saved for elution. The remainder of the paper is sprayed with a solution of 2% sodium carbonate. This decolorizes the brown iodoplatinate reagent and furnishes the necessary alkalinity for the reaction of primary amine with dinitrofluorobenzene. The paper is then sprayed with 0.5% alcoholic solution of this reagent. The presence of an aliphatic amine, such as amphetamine, is indicated when deep yellow areas appear that remain colored after dipping the dried paper in dilute hydrochloric acid (1:4). As little as 5 micrograms of aliphatic amine can be located on the paper. The deep yellow areas are readily eluted from the paper with chloroform yielding a yellow solution. Brown yellow areas due to other impurities are not eluted to give this yellow solution.

Fresh drug-free samples of tissue, especially liver, when carried through the above procedure will contain small amounts of basic compounds. These compounds appear when present as a fast-moving component (Fig. 2). They can be located as a dark band under ultraviolet light and will form a black spot after spraying with iodoplatinic acid reagent. Another compound will appear after spraying with dinitrofluorobenzene indicating an aliphatic amine. The latter compounds are present in large amounts after putrefaction and will be in such high concentration as to give dark compounds with iodoplatinic acid.

## Elution of Basic Drug

The blue or black area present after spraying with iodoplatinic acid reagent indicates only the presence of a basic compound. To identify this compound, other chemical and physical tests must be made.

*Procedure.* The dark areas are cut out and placed in a small separatory funnel. Three ml. of 0.5 N NaOH and approximately 0.2 gm. of sodium sulfite is added, completely wetting the paper. After about 5 minutes the iodoplatinate complex of the basic compound is destroyed, releasing the free base. To recover this compound, a solvent ether or chloroform is added to the separatory funnel, and shaken for a few minutes. The clear solvent containing the basic compound is evaporated to a small volume then air dried. The residue contains the free base in a highly purified state. Examination of the characteristic ultraviolet spectra of the residue will readily determine the presence or absence of many drugs (4). The

use of the sensitive color and crystal tests can be used either before or after examination of ultraviolet spectra (1).

## Summary

A simple rapid procedure for determining the presence or absence of basic drugs is presented. The tissue sample is directly extracted with ether. A purification and identification technique using paper ionophoresis is described. The sample of tissue is small (50 gms.) and the procedure can detect microgram quantities of basic drugs.

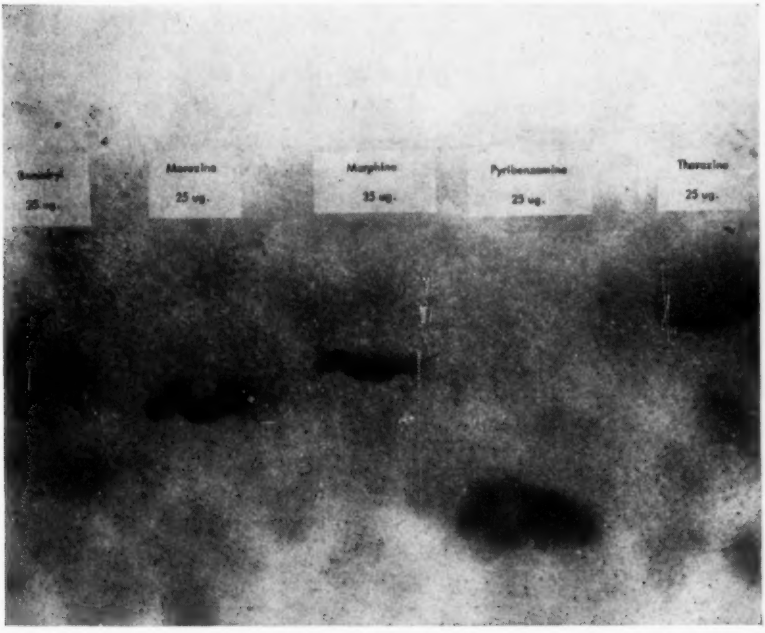


Fig. 4—Iodoplatinate spots showing the movement and intensity of 25 micrograms of some representative basic drugs. The applied voltage was 6005. and the time was 1 hour.

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Armed Forces Institute of Pathology
Forensic and Aviation Pathology Section
Washington, D. C.

# Extraction of Alkaloids from Tissue*

## A Modified Procedure for Purification Using a Non-aqueous Solvent in the Continuous Extractor Apparatus

*Harry Schwartz, B.Sc., and David Posnick, B.Sc.,** New York, New York*

Improvements have been made in the previously described continuous extraction method (1, 2) separating and recovering morphine and related alkaloids. A purer product has been obtained with maximum recovery of the alkaloid.

The apparatus consists of a slightly modified Soxhlet apparatus. The glass extraction tube with a course sintered glass filter contains a filter paper thimble into which is placed the homogenized tissue. The tissue is agitated by means of compressed nitrogen through the air inlet tube and the tissue is extracted with 95% ethanol for 3 to 4 hours. The alcohol extract is placed in the ice box and cooled to 35 degrees Fahrenheit for 12 to 15 hours. An asbestos filter mat is prepared in a Buchner funnel and the ice cold alcohol extract is filtered by suction. The clear alchohol solution is evaporated on the steam-bath to about 75 ml. volume. Any precipitate formed is redissolved by heating on a steam bath and adding a small amount of 95% ethanol. After cooling to room temperature, 600 ml. of 95% ethanol are added slowly with stir-

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** Division of Laboratories, Office of the Chief Medical Examiner of the City of New York.

ring. A gummy precipitate should not be formed. If one does, decant the alcohol, and dissolve the gummy precipitate by adding about 40–50 ml. water and heating on the steam bath. Then slowly add the decanted alcohol to the redissolved precipitate. One hour later, this is filtered through Whatman #1 filter paper.

The filtrate is evaporated on the steam bath to about 50 ml. volume. Any precipitate formed is redissolved in hot 95% ethanol. Cool and slowly add about 500 ml. acetone: let stand one hour and filter through Whatman #1 filter paper. Evaporate the filtrate on the steam bath to just dryness. Cool to room temperature. Make a solution of 50%–50% (volume–volume) n-butyl alcohol and benzene. Add 250 ml. of this mixture to the evaporating dish containing the residue and warm slightly on the steam-bath. Decant this n-butyl alcohol-benzene into a 500 ml. separatory funnel. Take up the remaining undissolved residue in the evaporating dish with about 150 ml. of 0.1 normal hydrochloric acid and decant into the separatory funnel containing the n-butyl alcohol benzene mixture again. Shake the separatory funnel containing the n-butyl alcohol benzene and acid water for about 3 minutes. Allow to stand for 15 minutes and then collect the water layer. Discard the n-butyl alcohol-benzene and shake the 0.1 normal hydrochloric acid water layer a second time with about 150 ml. of the 50–50 n-butyl alcohol-benzene mixture for about 3 minutes. Allow to stand 15 minutes and again discard the n-butyl alcohol benzene layer.

To the 0.1 normal hydrochloric acid water layer add 150 ml. ethyl ether and shake for 3 minutes. Let stand 15 minutes. Separate and evaporate the ether layer for the acid ether soluble group.

Make the acid water portion alkaline to a pH 10 with concentrated sodium hydroxide and shake this with 150 ml. ethyl ether for about 3 minutes. Allow to stand 15 minutes and separate. Wash the ether with 5 to 10 ml. of distilled water. Separate. Pour the ether into a beaker labelled "Alkaline fraction" and evaporate.

Acidify the alkaline water layer with concentrated sulfuric acid and then add concentrated ammonium hydroxide to pH 8. Cool to room temperature and shake for 3 minutes with 150 ml.

ethyl ether in a separatory funnel. Allow to stand 15 minutes and separate. Wash the ether layer with 5–10 ml. of distilled water. Separate and evaporate ether in beaker labelled "Ammonium hydroxide fraction."

The usual tests could now be performed on the alkaloidal residues in the "Alkaline fraction" and "Ammonium hydroxide fraction" beakers.

Color tests with the normally employed alkaloidal reagents were positive for 0.67 mgm. morphine, codeine, etc., in 500 grams of brain tissue.

The methyl orange coupling method (3) gave a positive and quantitative reaction for 0.67 mgm. codeine in 500 grams of brain tissue. Negative brain tissue gave no methyl orange color.

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Division of Laboratories
Chief Medical Examiner
New York, New York

# A Central Registry of Forensic Pathology*

*William M. Silliphant, Captain, MC, USN* **

A Registry of Forensic Pathology recently has been established at the Armed Forces Institute of Pathology under the sponsorship of the College of American Pathologists. It will be the 24th component registry of the American Registry of Pathology. The College of American Pathologists thus becomes the 19th of the national medical, dental and veterinary organizations in the support of the activities of the American Registry of Pathology; and the 7th such sponsor to award a Fellowship at the Armed Forces Institute of Pathology in the specialty of its particular interest.

**Basic Concepts of a Registry**

Through the medium of the National Research Council which was brought into the picture in order to facilitate liaison, the American Registry of Pathology functions as a cooperative enterprise between the Armed Forces Institute of Pathology and civilian medicine. Originally established in the early nineteen twenties, its paramount objectives have been the collection of pathologic material on certain specified categories of diseases for teaching, study and research, with dissemination of the findings to the medical profession by means of the publication of scientific papers, lectures by the staff, the display of scientific exhibits and the preparation of teaching manuals and microslide loan study sets.

The basic concept in setting up the new Registry of Forensic Pathology was to provide a central repository of well documented forensic pathology cases which would be available for teaching and research, in the manner more or less as stated for the other registries. In the creation of such a registry, it was natural, therefore, that the American Registry of Pathology should have been approached by the sponsoring agency with the expectation of adding another to its list of component registries.

**Functions of the Registry**

The functions of the Registry and some of the benefits to be anticipated from the collected cases would be:

1. To provide a central source of teaching materials in forensic medicine and pathology for medical schools, workshops, and seminars—such as microslides, lantern slides, photographs, and exhibits;

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** Director, Armed Forces Institute of Pathology, Washington, D. C.

2. To carry out research on unsolved problems of forensic pathology;
3. To standardize coding system, forms, autopsy protocols and toxicological reports;
4. To serve as a point of reference for the pathologists as an expert witness, whether for the prosecution or the defense, *or* as a defendant;
5. To stimulate medical examiners and pathologists in certain instances to do a more complete case study, with adequate utilization of photographs, x-rays and toxicological studies for submission to the Registry as a teaching case;
6. To serve as a point for international liaison with medico-legal institutions of other nations and perhaps working with them for international standardization of forensic medical procedures;
7. To accumulate data for publication; and
8. To provide for the support of a Fellow in forensic pathology at the Registry.

**Submission of Cases**

Cases submitted should be completely worked up and fully documented. They should be forwarded to The Director, Armed Forces Institute of Pathology, Attention: Forensic Pathology Section. Plastic bags are the preferred containers for wet tissue, which in all instances should be properly fixed. Each case must be accompanied by a complete clinical history which includes the circumstances surrounding death; a complete autopsy protocol including pertinent gross, microscopic, x-ray, and toxicological findings (if the latter are indicated); and photographs of the scene of the accident or other violence. X-rays and photographs will be duplicated and the originals returned to the contributor if so desired. Each case should include a separate concise statement of the medico-legal problem bearing on the contribution, with a report of the final ending. Only well selected cases of medico-legal interest, contributed by a qualified pathologist will be registered. All acceptable cases will be classified, registered, given an AFIP accession number, and acknowledged. All such material will be incorporated in the files of the Armed Forces Institute of Pathology and become a part of its national collection of pathology under the custodial jurisdiction of the Institute Director.

**Type of Cases Desired**

The type of case will depend usually upon the judgment of the contributor guided by information emanating from the Registry from time to time. For a guide line, the following types of cases would be desired:

1. Therapeutic and diagnostic misadventures;
2. Unusual suicides, homicides and accidents;
3. Poisonings whether homicidal, suicidal or accidental;
4. Cases in which court trials have been provoked from civil or criminal standpoints, providing the autopsy data plays a part in the trial;
5. Infections and tumors which appear to be directly associated with traumatic exposure; and
6. Any case judged by the contributor to be worthy of registration.

**Medico-Legal Opinions Not Given**

In negotiations between the Armed Forces Institute of Pathology and the College of American Pathologists in setting up the Registry, there was an acute awareness that such a Registry might be mistakenly regarded primarily as a consultation agency, where the contributing pathologist could freely obtain expert medical opinion, to assist him in court proceedings. Such is not the function of this new Registry, nor would there be an adequate number of qualified professional personnel in the Forensic Pathology Section to carry out such a service as might conceivably develop in an arrangement of this nature.

The registrar therefore will not be expected to render medico-legal opinions to the contributor, as to the cause of death or other statements concerning the case, which might render Armed Forces Institute of Pathology staff members liable to legal entanglements or to court proceedings. As it is expected that most cases will be contributed completely worked up by experienced pathologists qualified in forensic pathology, no such statements would ordinarily be desired nor expected.

**Basic Pathology Interpreted**

The registrar may upon request, however, provide the contributor with an interpretation of the basic pathology stemming from the staff's review of the gross and microscopic material accompanying the case. For instance, opinions may be given concerning the nature of liver damage and the probable etiologic agent involved; estimates regarding the probable age of a brain hemorrhage; or a statement verifying the identification of powder residues in a wound. Medico-legal opinions as to the mechanism of how such pathology was acquired, however, will not be a part of the report.

Furthermore, in cases where the interpretation of the basic pathology indicates errors, a miscarriage of justice or conditions overlooked, the registrar would, without request, voluntarily render a report to the contributor calling his attention to such discrepancies.

**Summary**

This article has been written to bring to the attention of pathologists engaged in the field of forensic medicine the creation of a Central Registry of Forensic Pathology, and to give them a general idea of the manner in which the Registry will operate, as agreed upon by the College of American Pathologists, the Armed Forces Institute of Pathology and the Committee on Pathology of the National Research Council. As the Registry has been organized primarily for teaching, research and the advancement of scientific knowledge, and as the success of a registry is dependent upon the enthusiasm with which qualified individuals contribute to the collection, it is hoped that pathologists engaged in this work will actively support this new Registry by the contribution of some of their better teaching cases.

Armed Forces Institute of Pathology
Washington, D. C.

# ELEVENTH ANNUAL MEETING

# AMERICAN ACADEMY OF FORENSIC SCIENCES

Drake Hotel, Chicago, Illinois
February 26, 27, 28, 1959

## PRELIMINARY PROGRAM

**Thursday, February 26, 1959**

SYMPOSIUM—DEVELOPMENTS IN FORENSIC SCIENCE IN 1958

| | |
|---|---|
| **Criminalistics** | **Joseph D. Nicol, M.S.**<br>**East Lansing, Michigan** |
| **Immunology** | |
| **Jurisprudence** | **Arthur H. Coleman, M.D., LL.B.**<br>**San Francisco, California** |
| **Pathology** | **Joseph Davis, M.D.**<br>**Miami, Florida** |
| **Psychiatry** | **Allen W. Byrnes, M.D.**<br>**Danville, Illinois** |
| **Questioned Documents** | **Linton Godown**<br>**Memphis, Tennessee** |
| **Toxicology** | **Irving Sunshine, Ph.D.**<br>**Cleveland, Ohio** |

BUSINESS MEETINGS OF SECTIONS FOLLOWED BY SECTIONAL MEETINGS IN

- **Pathology**
- **Toxicology**
- **Criminalistics**

GENERAL BUSINESS MEETING

MEETING OF 1960 PROGRAM COMMITTEE

PATHOLOGY SECTION MEETING

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|---|---|
| **The "General Unknown" as Seen from the Viewpoint of the Toxicologist** | **Frederick Reiters, Ph.D**<br>**Philadelphia, Pennsylvania** |
| **Perforating Lesions of the Esophagus and Their Relation to Trauma** | **Gale E. Wilson, M.D.**<br>**Seattle, Washington** |

**Friday, February 27, 1959**

SYMPOSIUM—SUICIDE

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|---|---|
| **1. Criminalistic Aspects** | **James W. Osterburg**<br>**New York, New York** |
| **2. Pathologic Aspects** | **Samuel Sanes, M.D.**<br>**Buffalo, New York** |

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| 3. | Toxicologic Aspects | Arthur J. McBay, Ph.D.<br>Boston, Massachusetts |
| 4. | Questioned Documents | James V. P. Conway<br>San Francisco, California |

5. Discussion of Laboratory Examinations in Suicide Investigations
Dubowski, Osterburg, and Conway

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| 6. | Psychiatric Aspects | Dwight M. Palmer, M.D.<br>Columbus, Ohio |
| 7. | Legal Aspects | Orville Richardson<br>St. Louis, Missouri |

FRIDAY EVENING—ANNUAL BANQUET

Saturday, February 28, 1959

SCIENTIFIC SECTION MEETINGS

PATHOLOGY

Administrative Problems Encountered in Establishing a New Medicolegal System:

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| 1. | Problems relating to physicians, hospitals, law enforcement agencies and allied groups | Daniel Condon, M.D.<br>Phoenix, Arizona |
| 2. | Problems relating to families of the decedents and funeral directors | Theodore Curphey, M.D.<br>Los Angeles, California |
| 3. | Problems relating to personnel and facilities. "How much does a system need for survival?" Demonstration of Gross and Microscopic Forensic Pathology | Charles Petty, M.D.<br>Baltimore, Maryland |

TOXICOLOGY

Symposium on Recent Developments in Toxicological Methodology

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|---|---|
| Dr. Frederic Rieders | Volatile Substances |
| Dr. Milton Feldstein | Volatile Substances |
| Dr. Alan Eagleston | Inorganic Anions and Cations |
| Dr. Sidney Kaye | To be announced |
| Dr. George Stevenson | Isolation, Purification, and Identification of Barbiturates |
| Dr. Frederic Rieders | Isolation of Organic Acids and Bases |
| Dr. Gilbert Mannering | Isolation, Purification, and Identification of Organic Bases |
| Raymond Abernathy | Isolation, Purification, and Identification of Organic Bases |
| Dr. Morton Mason | To be announced |
| Dr. Abraham Stolman | Identification Using Infra-Red Spectrophotometry |
| Dr. Louis A. Williams | Identification Using Ultra-Violet Spectrophotometry |